EXHIBIT 72

- Combination of uncertainty through the process of coupling air emissions, unsaturated zone transport, groundwater flow, and groundwater transport models as illustrated in Figure 10.
- Hydrogeological complexity.
- Local conduit flow conditions.
- Uncertainty in well construction and the location(s) of productive zones in bedrock wells, including leakage through or around the bottom of the well casing.
- Vertical variability in PFOA concentrations (particularly in bedrock).
- PFOA originating from other sources.

6.2.5.1 Private Wells and Former Chemfab Facility Monitoring Wells

Considering the overall purpose of the evaluation, the variability in the PFOA data, and discussion in the previous section, the groundwater transport simulation results are a good overall approximation of the measured PFOA concentrations at private wells and the monitoring wells at the former Chemfab facility on Water Street, with the exceptions noted in the preceding subsection. For purposes of this report, the modeled process and parameters provide a conservative estimate of potential PFOA associated with emissions from the former Chemfab facilities, as well as illuminate areas where the air deposition and groundwater transport processes cannot explain the presence and distribution of PFOA in wells and where other sources, such as landfills or other industrial activities, are the likely a source for the detected PF compounds.

6.2.5.2 Bennington Landfill Monitoring Wells

The groundwater transport simulation results do not compare well with measured PFOA concentrations at Bennington Landfill monitoring wells or private wells located south and southwest of the Bennington Landfill (Figure 19). This is the basis for the conclusion that the measured PFOA concentrations south and southwest of the landfill are likely from another source. Considering the disposed materials, the history of disposal practices, and the current concentration of PFOA in the landfill leachate, the landfill is considered a likely source of the measured PFOA concentrations south and southwest of the landfill.

Simulated groundwater flow from the landfill through bedrock also suggests that Bennington Landfill is a likely source of PFOA detection at the private wells south and southwest of the landfill. Simulated migration of groundwater from Bennington Landfill is shown on Figure 21. The difference in flow direction between the unconsolidated sediments and the bedrock is apparent in the direction of migration of groundwater in the model layers corresponding to these materials. While flow in the unconsolidated sediments is primarily toward the southeast to Hewitt Brook, flow in the bedrock is primarily to the south and southwest. The bedrock flow directions in the vicinity of the Bennington Landfill indicated in Figure 21 shows good agreement with bedrock flow directions indicated by a recently published groundwater elevation contour map (Kim and Dowey, 2017).

Figure 22 shows a cross section of groundwater flow from Bennington Landfill to the Walloomsac River, which illustrates the perched flow system at the landfill and also the variability in materials through which the groundwater flows.

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6.2.6 Delineation of Corrective Action Area 1

The results of the simulations have been compared to measured PFOA concentrations in groundwater within the study area to identify areas where exceedances of regulatory standards potentially may be associated with historical air emissions from the former Chemfab facilities. For purposes of this report, a simulated affected area is an area in which the simulated PFOA concentration for 2016 is greater than the State's DWHA of 20 ppt. These areas are shown on Figure 19 for the air emissions scenario evaluated.

The model results show areas of PFOA in groundwater in 2016 extending north, south, and to the southeast of the former Water Street Chemfab facility. The model results are consistent with areas of PFOA detections except near the Bennington Landfill where PFOA was detected and in areas of no detected PFOA south and east of the former Water Street Chemfab facility. The modeling does not account for the effects of land application of PFOA-containing WWTP sludge on agricultural fields (the locations of which are not known at this time), other industrial and commercial sources (Section 5.1.6), and the possible effects of transport in surface water (such as the Walloomsac River) and bank infiltration with subsequent groundwater withdrawals from wells adjacent to the river.

6.2.7 Sensitivity Analyses

Sensitivity analyses were performed on the air, unsaturated zone, and groundwater models to assess the effects of parameter uncertainty on model results. The process and results of these sensitivity runs are discussed in the following sections and in the corresponding appendices describing model setup.

6.2.7.1 Air Emissions and Deposition

Appendix A provides discussion of the sensitivity analyses conducted for the air deposition analysis. Results from the air model sensitivity analysis show:

- The model results are very sensitive to the particle deposition methodology employed. The method used to define the deposition parameters used in this analysis is conservative with respect to mass deposition (i.e., mass deposition is maximized in the model domain) relative to other available methods for defining the parameters.
- The model results are sensitive to the emission rate; the results are linear with respect to emission rate.

6.2.7.2 Unsaturated Zone and Groundwater Transport

For purposes of this report, the unsaturated zone and groundwater transport models were simulated under various combinations of transport parameter values to assess the effect of parameter uncertainty on the simulated extent and magnitude of PFOA detection in groundwater. The parameter values and model results for the sensitivity runs are provided in Appendix D.

Results from the unsaturated zone and groundwater transport model sensitivity analysis show:

- Varying transport parameters within reasonable ranges in most instances did not substantively change the overall agreement between modeled and measured PFOA concentrations.

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- The variation in the transport parameters does not result in PFOA concentrations at the landfill wells being simulated at measured levels, indicating the presence of another source contributing to PFOA detection in the area.
- Composite parameter sensitivity values show that recharge, K_{oc}, and f_{oc} in unsaturated zone model are the most sensitive parameters.

Dual-porosity processes (also referred to as matrix-diffusion processes), are known to be applicable in both granular aquifers (Bianchi and Zheng, 2016) and fractured rock aquifers (Neville and Bedekar, 2016). Dual porosity and matrix diffusion processes can cause a conservative solute to act in non-conservative ways, such as slower transport velocities than advective flow velocities and tailing effects. PFOA is not assumed to be conservative in the unsaturated transport modeling, therefore, dual porosity and matrix diffusion processes are discussed below only for the saturated transport modeling.

Adopting a dual-domain approach in the saturated transport model would have involved dividing the effective porosity used as input into two compartments: mobile porosity and immobile porosity. No area-specific information is available with which to base this division. Advection rates would be higher in the mobile porosity in this modeling approach since it is only a portion of the effective porosity, but for a non-sorbing solute, the net transport rates during mass loading would be lowered by mass transfer from the mobile porosity to the immobile porosity until the concentration gradient dissipated (retardation of the solute transport rate). If a source is cut off in such a system, solute concentrations in the mobile porosity decline more slowly as mass is transferred from the immobile porosity back to the mobile porosity (tailing effects). In other words, there are offsetting effects of accounting for dual domain transport. The sensitivity analysis on effective porosity (Appendix D, Section 2.5) implicitly includes the effects that would be produced by dual porosity and matrix diffusions processes.

These results support the use of the selected parameter values to assess PFOA fate and transport in the unsaturated and saturated zones, and illustrate the limited sensitivity of the main model outputs (e.g., the magnitude and extent of PFOA in groundwater that may have resulted from air emissions) to other parameters.

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7.0 Multivariate Analyses of PFAS Data

For purposes of this report, PFAS data that have been collected as part of the ongoing monitoring and investigation of groundwater from wells and soils and POET influent data were processed using several statistical tools to determine if there were patterns outside of spatial considerations that could be used to identify groups or "families" of samples. By using multivariate analysis (MVA) statistical approaches on the available dataset, previously latent (unrecognized) relationships between samples may identify potentially separate sources of PFAS, or may potentially identify the likelihood of a common source.

MVA is a well-established set of statistical methods for evaluating data involving more than one variable. Various MVA procedures were applied to the data from the Bennington area in order to discern any patterns to the data and any relationships between data points, based solely on the composition of the PFAS compounds that were detected. For purposes of this report, the statistical add-on tool to Microsoft Excel, XLStat (www.xlstat.com), was used in the MVA procedures.

The presence of non-detect concentrations requires assignment of data values. Detection limits may be different for different compounds and for different samples. For purposes of this report, a non-detect result was treated as a value of zero ppt.

7.1 Agglomerative Hierarchical Cluster Analysis

Agglomerative Hierarchical Cluster (AHC) analysis involves evaluating the data (i.e. multiple PFAS compounds from many locations) without any consideration to mechanisms, physical processes, trends, or spatial location. AHC analysis seeks to identify which data locations are similar to other locations and groups or "clusters" like-data based on statistical thresholds. AHC is a statistical iterative classification method which produces a dendrogram (clustering tree), representing a hierarchy of objective similarities and dissimilarities. The agglomerative methodology used is Ward's method using Euclidian distance proximity. Truncation of the AHC was conducted manually and favored fewer groups with larger populations over many groups with smaller (or single) populations.

PFAS data were selected from the available groundwater, soils, and POET influent data and transformed in the following manner prior to analysis:

- The geographic location of the data within the study area was not a factor in data selection or statistical analysis.
- The data set for analysis by AHC was constrained to those data points with the six PFAS compounds analyzed as part of VTDEC private well sampling:
    - perfluorobutanesulfonic acid (PFBS),
    - perfluorohexanoic acid (PFHxA),
    - perfluorohexanesulfonic acid (PFHxS),
    - perfluoroheptanoic acid (PFHpA),
    - perfluorooctanesulfonic acid (PFOS), and
    - perfluorooctanoic acid (PFOA).

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- Concentrations of PFAS analytes less than the instrument detection limit (IDL) were replaced with values set to zero, as other methods of treating non-detect data generate data artifacts for the purposes of multivariate statistics that obfuscate clustering results due to varying reporting limits (RLs) between laboratories and sample volumes.
- PFAS analytes with reportable concentrations between the IDL and practical reporting limit (J-qualified) were not altered before processing with statistical software.
- Multiple observations made at a single location were treated as separate data points due to the amount of time between sample collections (approximately quarterly).
- The resultant dataset contained 295 data points at 218 locations.
- The data set was normalized to convert to fractional concentrations of the sum of PFAS measured and the resultant data was processed with XLStat for AHC. Data processed in this manner allowed for clustering with an emphasis on the total sample profile, diminishing the role played by absolute PFOA concentration and influences on absolute concentrations such as dilution and mixing.

Overall, six sub-groups were identified from the statistical clusters. Three of these sub-groups were combined due to the similarities in the data, forming four statistical sub-groups. The four sub-group descriptions are as follows;

- Group 1 – This sub-group had the highest detected levels of PFOS and PFHxS.
- Group 2 – This sub-group had the highest detected levels of PFOA and PFHpA and the lowest detected levels of PFOS.
- Group 3 – This sub-group had the lowest detected levels of PFOA and PFHpA and also had detections of PFHxS. In addition, this sub-group had the second highest detected levels of PFOS, PFHxA, and PFBS.
- Groups 4, 5, and 6 – This sub-group had the highest detected levels of PFOA and PFHpA without detectable levels of PFOS and PFBS.

Two main groups were identified from the four sub-groups identified by the AHC analysis on the basis of wells with or without sulfonated PFAS and wells with or without PFHxA (C6). The two main groups are described as (1) wells with PFOA and PFHpA and no sulfonated PFAS compounds and no PFHxA ("PFOA and PFHpA dominated") and (2) wells with sulfonated PFAS compounds ("Highest PFOS"). These well groupings and generalized extents are shown on Figure 23.

7.2 Principal Component Analysis

Principal Component Analysis (PCA) is another form of MVA that describes the data in terms of variability. PCA is independent of AHC and uses orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. The number of principal components is less than or equal to the smaller of the number of original variables or the number of observations. This transformation is defined in such a way that the first principal component has the largest possible variance (that is, accounts for as much of the variability in the data as possible), and each succeeding component in turn has the highest variance possible under the

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constraint that it is orthogonal to the preceding components. The resulting vectors are an uncorrelated orthogonal basis set. PCA is a close relative of another MVA method called "factor analysis".

The PFAS dataset for PCA analysis was selected and transformed in the same manner as for the AHC analysis described in Section 7.1. The resulting PCA plot is shown on Figure 24.

In general, the PCA identified two different groups of data that are likely related to different sources of PFAS in groundwater. PFOS, PFHxA, PFHxS, and PFBS are associated with Factor 1, which describes 42.45 percent of the variance in the data set. In contrast, PFOA and PFHpA are associated with Factor 2, which describes 32.51 percent of the variance. These PFASs are associated with each other because PFHpA (C7) is commonly found in trace amounts in products with higher concentrations of PFOA. The individual factor loadings for the parameters are as follows:

Parameter	F1 Loading (%)	F2 Loading (%)
PFBS	16.160	0.119
PFHpA	0.139	49.917
PFHxS	27.636	0.185
PFHxA	31.834	0.131
PFOS	23.818	0.090
PFOA	0.414	49.557

7.3 Discussion of Results

The two MVA analyses (AHC and PCA) suggest the following:

- Wells in the general vicinity of the former Chemfab facilities have PFAS detections that are predominantly PFOA/PFHpA and typically do not have sulfonated PFAS compounds. This profile would generally be consistent with a source of PFAS that would be similar to PFOA-based dispersion.
- Wells along Harwood Hill Road and in the vicinity of the Bennington Landfill are statistically grouped together because they generally contain detectable concentrations of PFHxA and sulfonated compounds such as PFOS, PFHxS, and PFBS and are not correlated with PFOA/PFHpA. This suggests a mixture of PFAS compounds from a variety of commercial, domestic, and industrial sources.
- The sporadic presence of wells with sulfonated PFAS compounds throughout the Bennington area indicates a greater statistical commonality with the wells in the Harwood Hill Road/Bennington Landfill area than wells in the vicinity of the former Chemfab facilities. This suggests a variety of localized, mixed PFAS sources.

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8.0 Summary

For purposes of this report, numerical models were developed to evaluate and simulate potential transport mechanisms of PFOA released by historical air emissions at the former Chemfab facilities in Bennington and North Bennington, Vermont that may have resulted in the presence of PFOA in soil and groundwater in the vicinity of these facilities. The results of the simulations have been compared to measured PFOA concentrations in soil and groundwater within the study area to identify areas where exceedances of regulatory standards potentially may be associated with historical air emissions from the former Chemfab facilities.

The modeling work and data evaluation described in this report are summarized as follows:

- Airborne emissions of PFOA from the former Chemfab facilities may have contributed to PFOA in groundwater in portions of the Bennington area. They cannot be the source of PFOA in other areas where PFOA has been detected in wells at concentrations above Vermont's drinking water health advisory level of 20 ppt, including areas to the south and southwest of the Bennington Landfill.
- Transport through the unsaturated zone likely produced a lag between the time PFOA was deposited at the ground surface and the time PFOA reached the water table.
- The overall pattern and distribution of groundwater elevations measured in wells and PFOA concentrations reported for groundwater samples from wells were simulated successfully. Simulated concentrations of PFOA in groundwater range from 0 ppt up to approximately 1,000 ppt in close proximity to the former Water Street Chemfab facility.
- The modeling indicates that the presence of PFOA in groundwater in the vicinity of Bennington Landfill is not the result of air emissions from the Chemfab plants. These results suggest that sources at the landfill are the likely source of PFOA and PFOS detected in wells south and southwest of Bennington Landfill.
- The modeled processes and values used as model inputs explain the patterns of PFOA concentrations, as well as illuminate areas where the air deposition and groundwater transport processes do not explain the presence and distribution of PFOA in wells and where other sources, such as landfills or other activities, are a more likely source for PFAS detections.
- There are numerous other potential sources of PFAS in the study area that were not included as PFAS sources for purposes of this report but which could be the source of PFAS in groundwater. These potential sources include a wide variety of commercial and industrial sites (e.g., car washes; landfills, granite, stone and tile finishing; storage and/or use of fire-fighting foam; wastewater treatment plants; wood floor finishing; automotive repair; junkyards; incinerators; carpet and upholstery cleaning; and painting/coating application); and sites that have used biosolids (e.g., agricultural fields; athletic fields; turf farms; landscaped areas; greenhouses; nurseries; and landscape and topsoil supply facilities).

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Tables

Table 1

PFUnA, PFTriDA, and PFTeDA Concentrations in Soil and Groundwater, former Chemfab Water Street

North Bennington, VT

Soil in ppb (ng/g), Groundwater in ppt (ng/l)

Location	Sample Date	Soil Depth or Groundwater	Perfluorotetradecanoic acid (PFTeDA, C14)	Perfluorotridecanoic Acid (PFTriDA, C13)	Perfluoroundecanoic Acid (PFUnDA, C11)
MW01	6/20/2016	0 ft	< 0.34 J	< 0.68 J	**0.45 J**
		0.5 ft	< 0.34 J	< 0.68 J	**0.35 J**
		1 ft	< 0.35	< 0.70	< 0.35
		1.5 ft	< 0.35	< 0.69	< 0.35
		3.5 ft	< 0.40 J	< 0.80 J	< 0.40 J
		8 ft	< 0.34	< 0.67	< 0.34
		13 ft	< 0.33	< 0.65	< 0.33
	12/19/2016	Groundwater	< 0.5	< 0.5	< 1
MW02	6/16/2016	0 ft	**74 J**	**6.6**	< 0.33
		0.5 ft	**93 J**	**15**	< 0.32
		1 ft	**40 J**	**15**	**1.0**
		1.5 ft	**11 J**	**6.5**	**1.8**
	6/17/2016	5 ft	**20**	**6.2**	**15**
		6 ft	**29**	**10**	**3.9**
		8 ft	**1.6**	< 0.74	**1.9**
		10 ft	**0.35 J**	< 0.69	**1.4**
	12/20/2016	Groundwater	< 5	< 5	**14 J**
MW03	6/15/2016	0 ft	< 0.32	< 0.64	< 0.32
		0.5 ft	< 0.32	< 0.63	< 0.32
		1 ft	< 0.32	< 0.64	< 0.32
		1.5 ft	< 0.32	< 0.65	< 0.32
		3.5 ft	< 0.34	< 0.68	< 0.34
		6 ft	< 0.37	< 0.75	**0.37 J**
		9.5 ft	< 0.38	< 0.75	< 0.38
	6/16/2016	11 ft	< 0.38	< 0.75	< 0.38
	6/15/2016	17 ft	< 0.36	< 0.73	< 0.36
	12/16/2016	Groundwater	< 0.5	< 0.5	< 1
MW03S	12/16/2016	Groundwater	< 0.5	< 0.5	< 1
MW04	6/16/2016	0 ft	< 0.32	< 0.63	< 0.32
		0.5 ft	< 0.33	< 0.67	**0.61 J**
		1 ft	< 0.32	< 0.64	< 0.32
		1.5 ft	< 0.32	< 0.64	< 0.32
		4.5 ft	< 0.37	< 0.74	< 0.37
		8 ft	< 0.36	< 0.72	< 0.36
		9.5 ft	< 0.32 J	< 0.64 J	< 0.32 J
		12.5	< 0.36	< 0.72	< 0.36 J
	12/16/2016	Groundwater	< 0.5	< 0.5	< 1
MW04S	12/16/2016	Groundwater	< 0.5	< 0.5	< 1

Case 5:16-cv-00125-gwc Document 219-75 Filed 11/27/18 Page 16 of 43

Table 1

PFUnA, PFTriDA, and PFTeDA Concentrations in Soil and Groundwater, former Chemfab Water Street

North Bennington, VT

Soil in ppb (ng/g), Groundwater in ppt (ng/l)

Location	Sample Date	Soil Depth or Groundwater	Perfluorotetradecanoic acid (PFTeDA, C14)	Perfluorotridecanoic Acid (PFTriDA, C13)	Perfluoroundecanoic Acid (PFUnDA, C11)
MW05	6/14/2016	0 ft	< 0.32	< 0.63	< 0.32
		0.5 ft	< 0.33	< 0.65	< 0.33
		1 ft	< 0.34	< 0.67	< 0.34
		1.5 ft	< 0.35	< 0.71	< 0.35
		3 ft	< 0.38	< 0.76	< 0.38
	6/15/2016	5 ft	< 0.37	< 0.74	< 0.37
		9 ft	< 0.36	< 0.73	< 0.36
	12/15/2016	Groundwater	< 0.5	< 0.5	< 1
MW06	6/14/2016	0 ft	< 0.32	< 0.64	< 0.32
		0.5 ft	< 0.31	< 0.62	< 0.31
		1 ft	< 0.32	< 0.64	< 0.32
		1.5 ft	< 0.33	< 0.66	< 0.33
	6/20/2016	5 ft	< 0.36 J	< 0.72 J	< 0.36 J
		10.5 ft	< 0.34 J	< 0.69 J	< 0.34 J
		13.5 ft	< 0.33	< 0.66	< 0.33
	12/19/2016	Groundwater	< 0.5	< 0.5	< 1
MW06S	12/19/2016	Groundwater	< 0.5	< 0.5	< 1
MW07	6/13/2016	0 ft	**0.44 J**	< 0.82	**0.83**
		0.5 ft	< 0.39	< 0.78	< 0.39
		1 ft	< 0.37	< 0.73	< 0.37
		1.5 ft	< 0.36	< 0.72	< 0.36
	6/14/2016	2.5 ft	< 0.37	< 0.74	< 0.37
		9.5 ft	< 0.32	< 0.63	< 0.32
		12 ft	< 0.33	< 0.67	< 0.33
		22 ft	< 0.35	< 0.70	< 0.35
	12/20/2016	Groundwater	< 0.5	< 0.5	< 1
MW07S	12/20/2016	Groundwater	< 0.5	< 0.5	< 1
1030 Water Street - Chemfab Blowdown East	3/23/2016	0 - 6 in	**25**	**15**	**1.1**
		6 - 12 in	**12**	**15**	**0.49 J**
		12 - 18 in	**3.7**	**15**	< 0.34
		18 - 24 in	**2.2**	**6.4**	**0.79**
1030 Water Street - Chemfab Along River	3/23/2016	0 - 6 in	**1.4**	**1.5**	**3.2**
		6 - 12 in	< 0.33	< 0.65	**0.63 J**
		12 - 18 in	< 0.34	< 0.67	**0.90**
		18 - 24 in	< 0.33	< 0.66	< 0.33
1030 Water Street - Chemfab Vent West	3/24/2016	0 - 6 in	**49**	**8.2**	**0.86**
		6 - 12 in	**23**	**7.1**	**2.9**
		12 - 18 in	**6.9**	**5.7**	**9.4**
		18 - 24 in	**5.7**	**5.0**	**3.9**
1030 Water Street - Chemfab West Side	3/23/2016	0 - 6 in	**17**	**7.4**	< 0.36
		6 - 12 in	**4.8**	**7.3**	< 0.33
		12 - 18 in	**1.6**	**4.2**	< 0.35
		18 - 24 in	**2.3**	**2.7**	**4.7**

Case 5:16-cv-00125-gwc Document 221-6 Filed 11/28/18 Page 17 of 43

Data Footnotes and Qualifiers

Barr Standard Footnotes and Qualifiers

J	Estimated result. Qualifier applied by Data Validator, not Barr Engineering Company.

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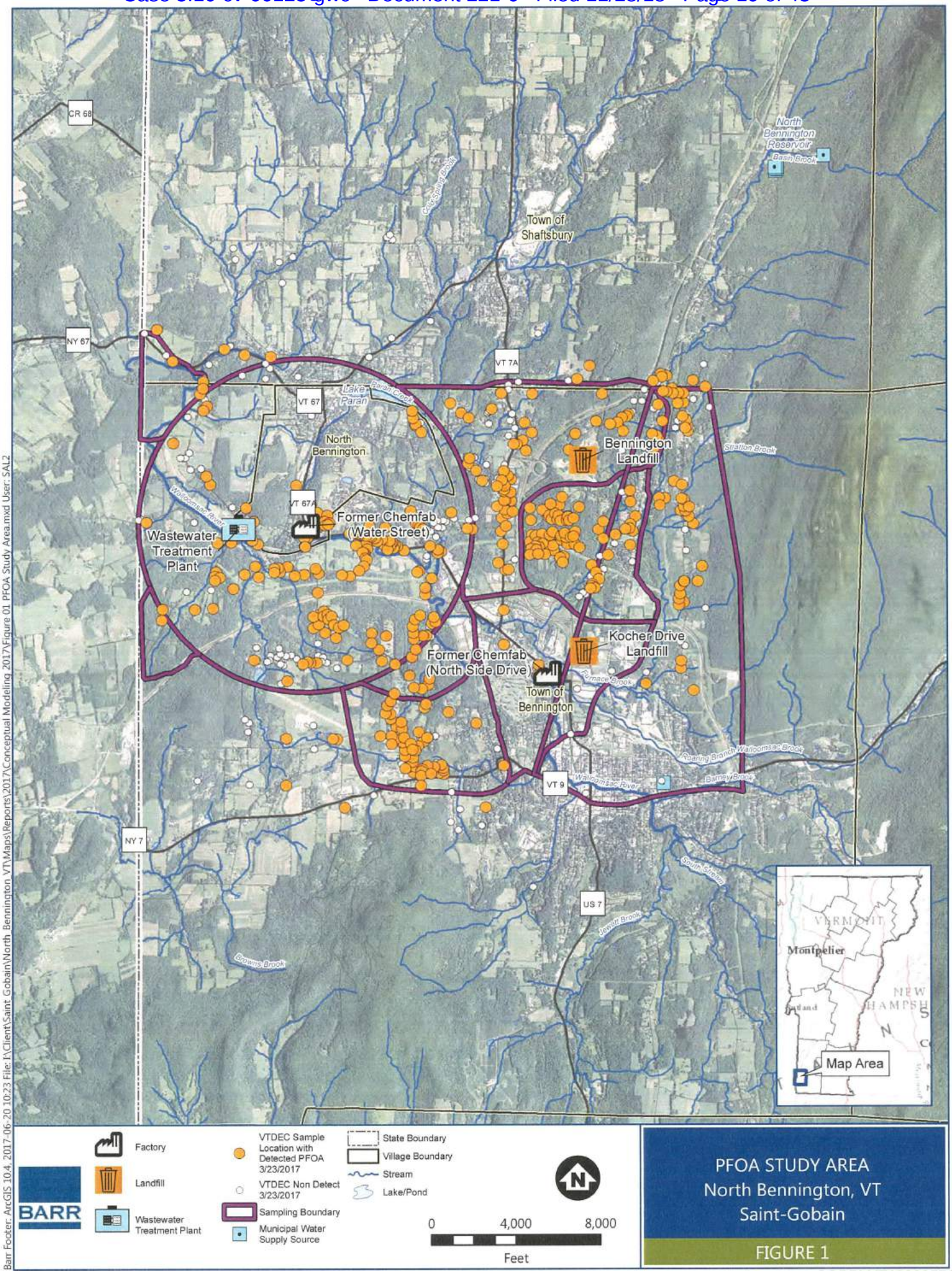
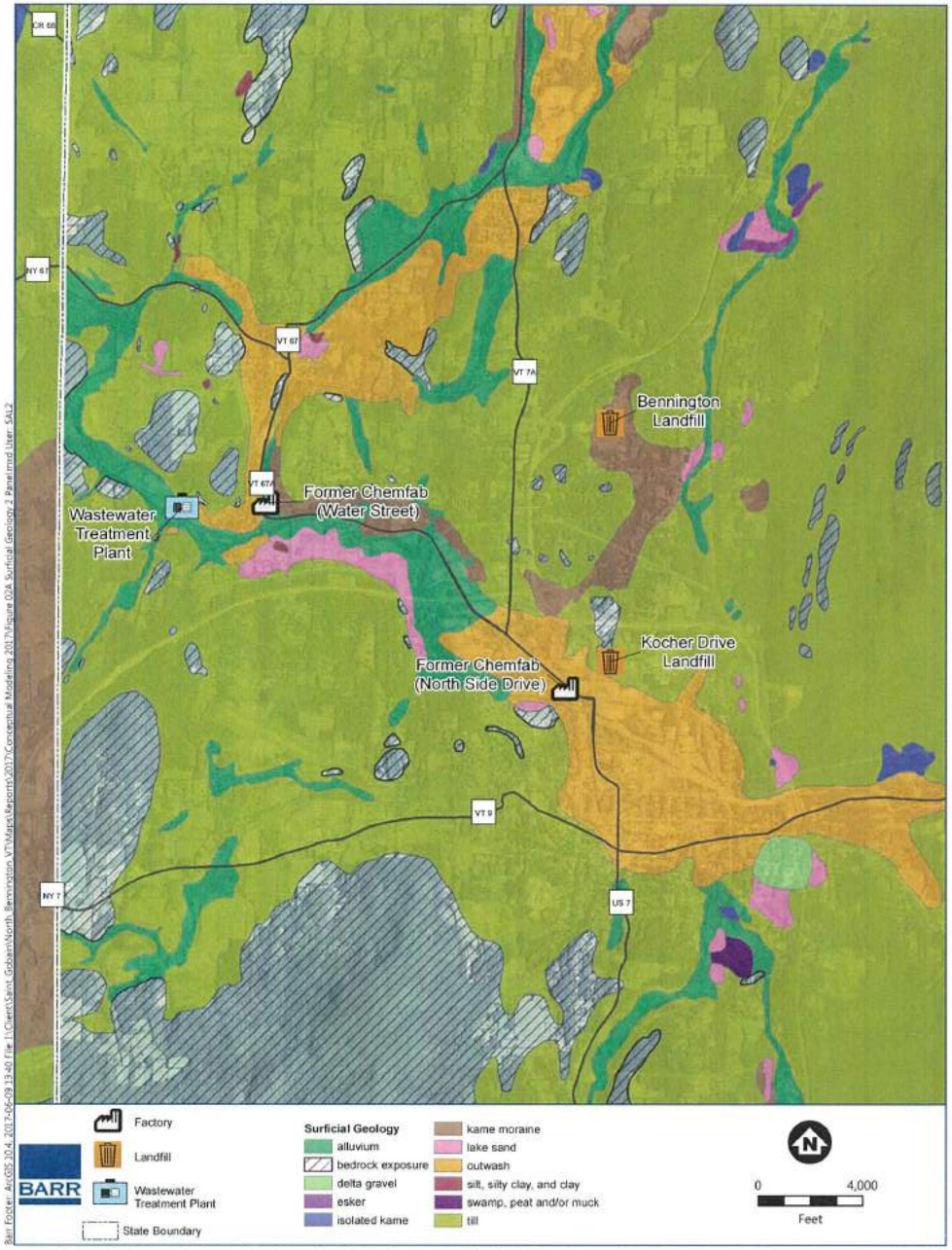
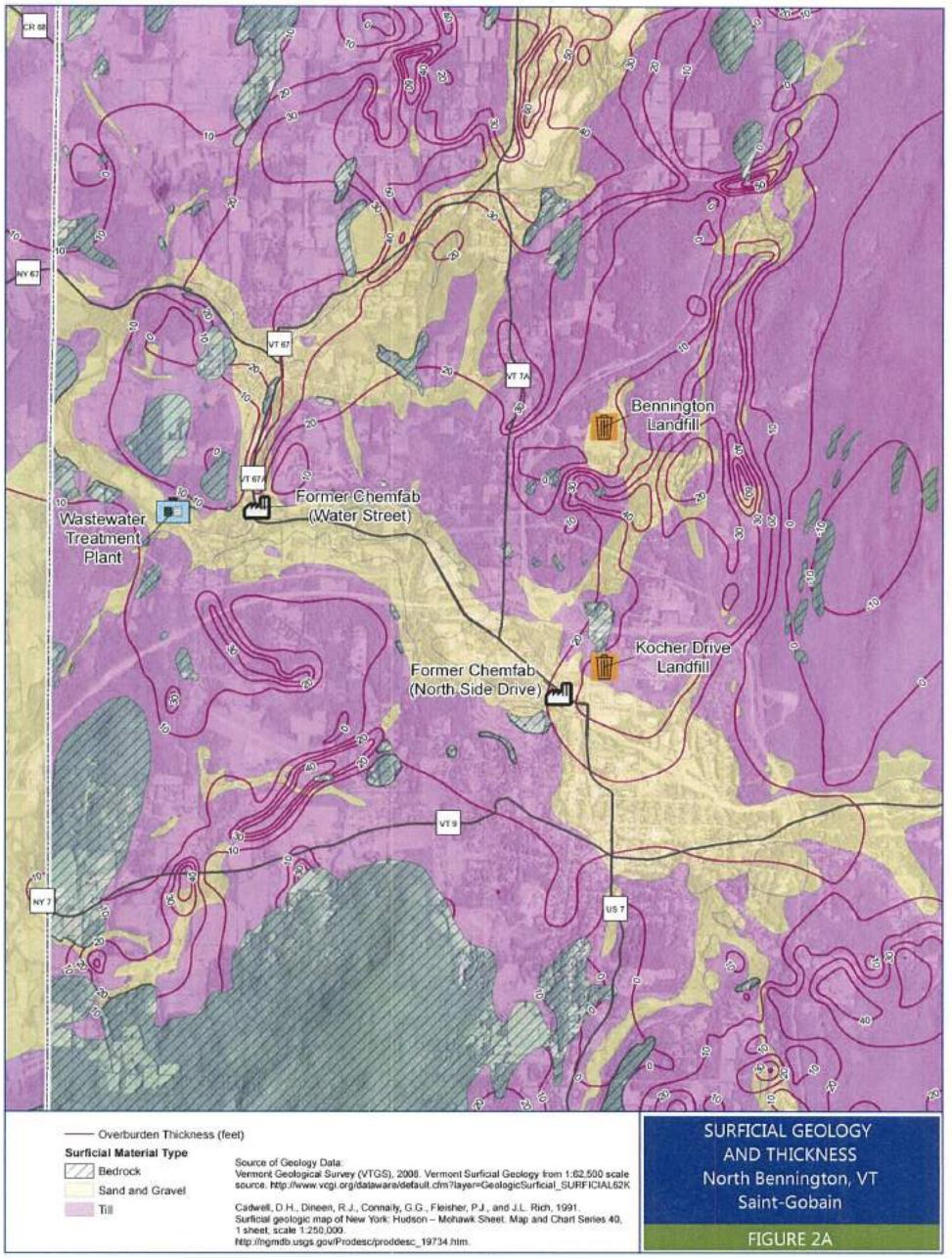
Figures



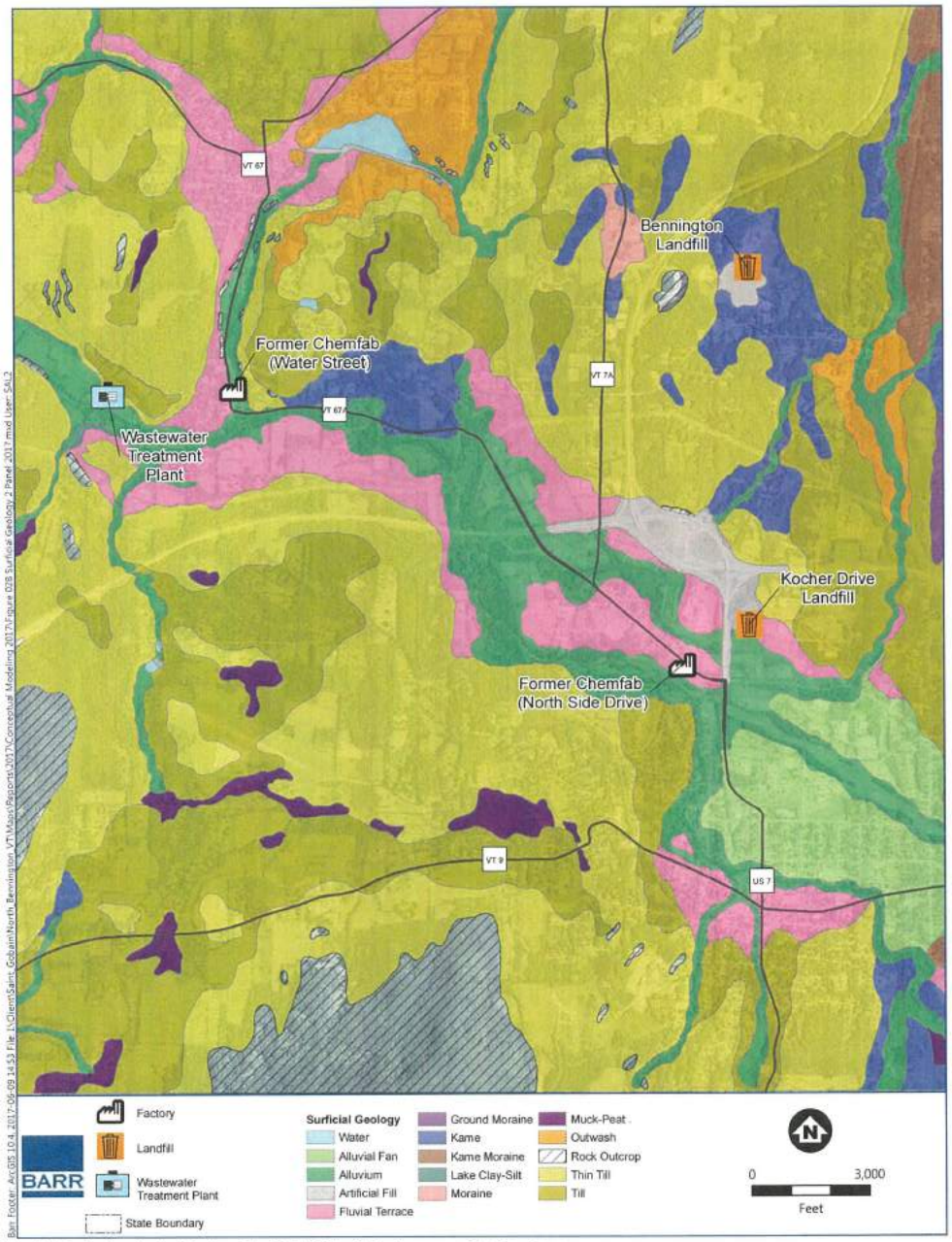
Barr Footer: ArcGIS 10.4, 2017-06-20 10:23 File: I:\Client\Saint Gobain\North Bennington VT\Maps\Reports\2017\Conceptual Modeling 2017\Figure 01 PFOA Study Area.mxd User: SAL2

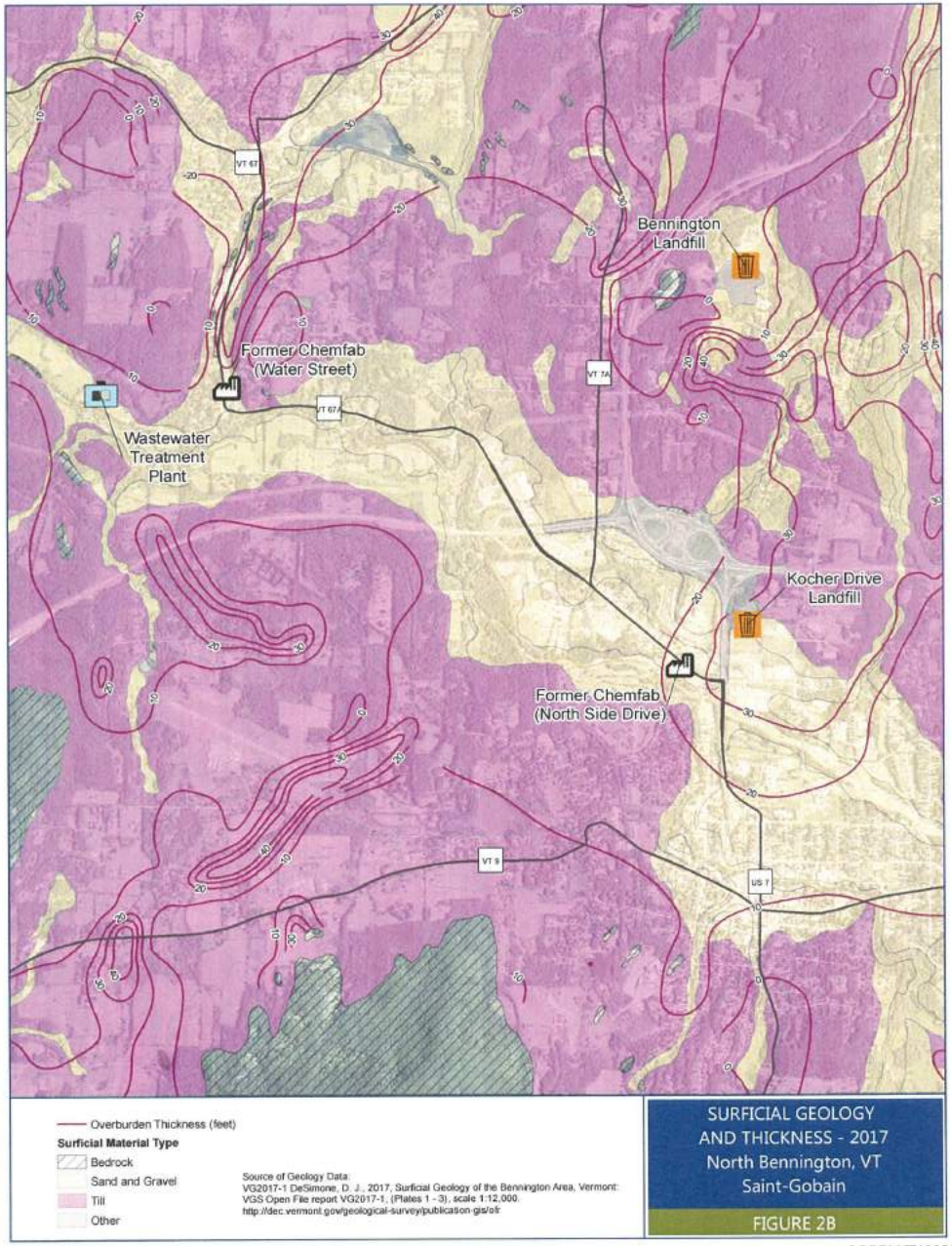




Subject to Protective Order, Produced by Saint-Gobain Performance Plastics, Corp.

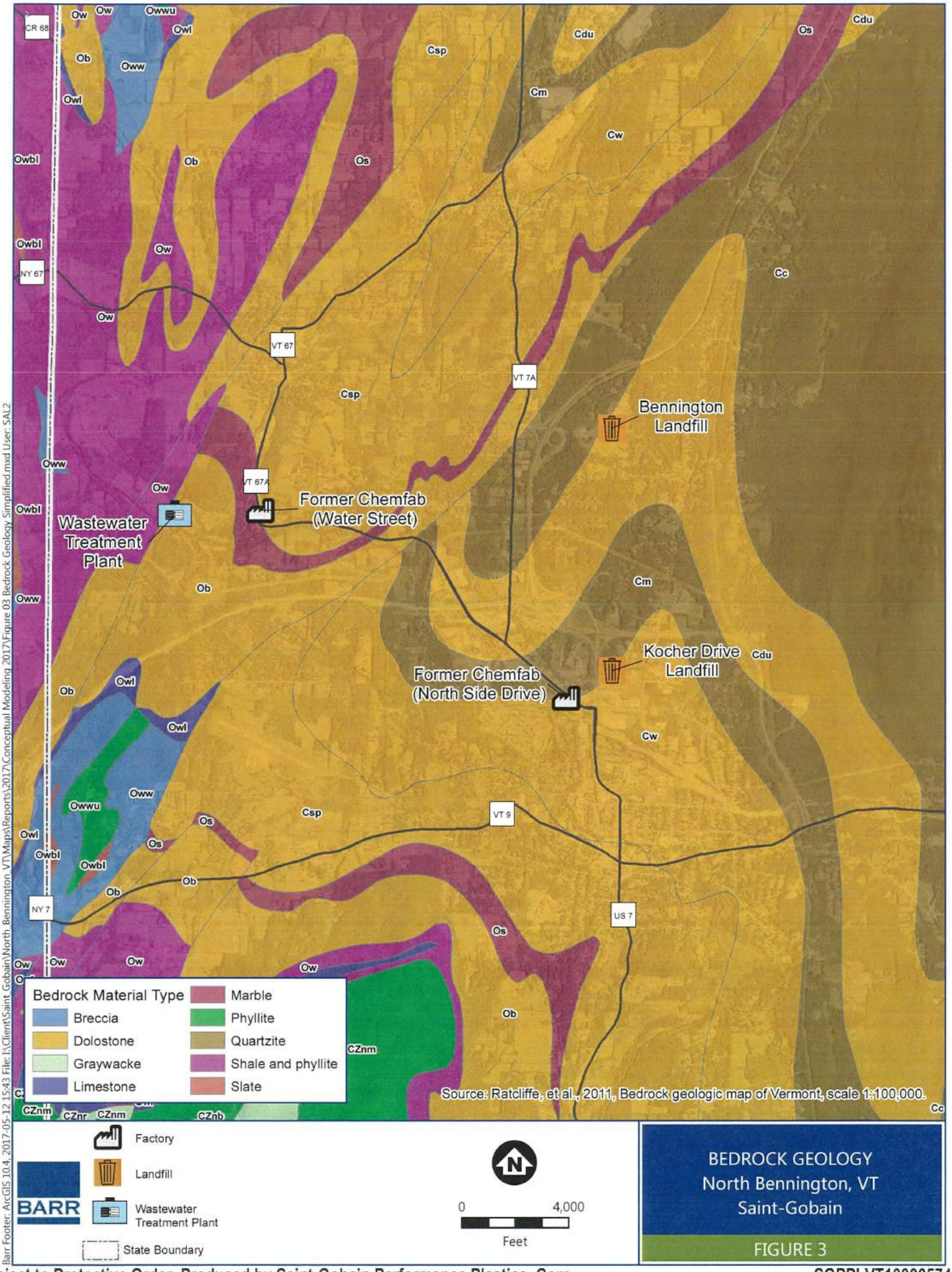
Case 5:16-cv-00225-gwc Document 229-75 Filed 11/26/18 Page 20 of 48

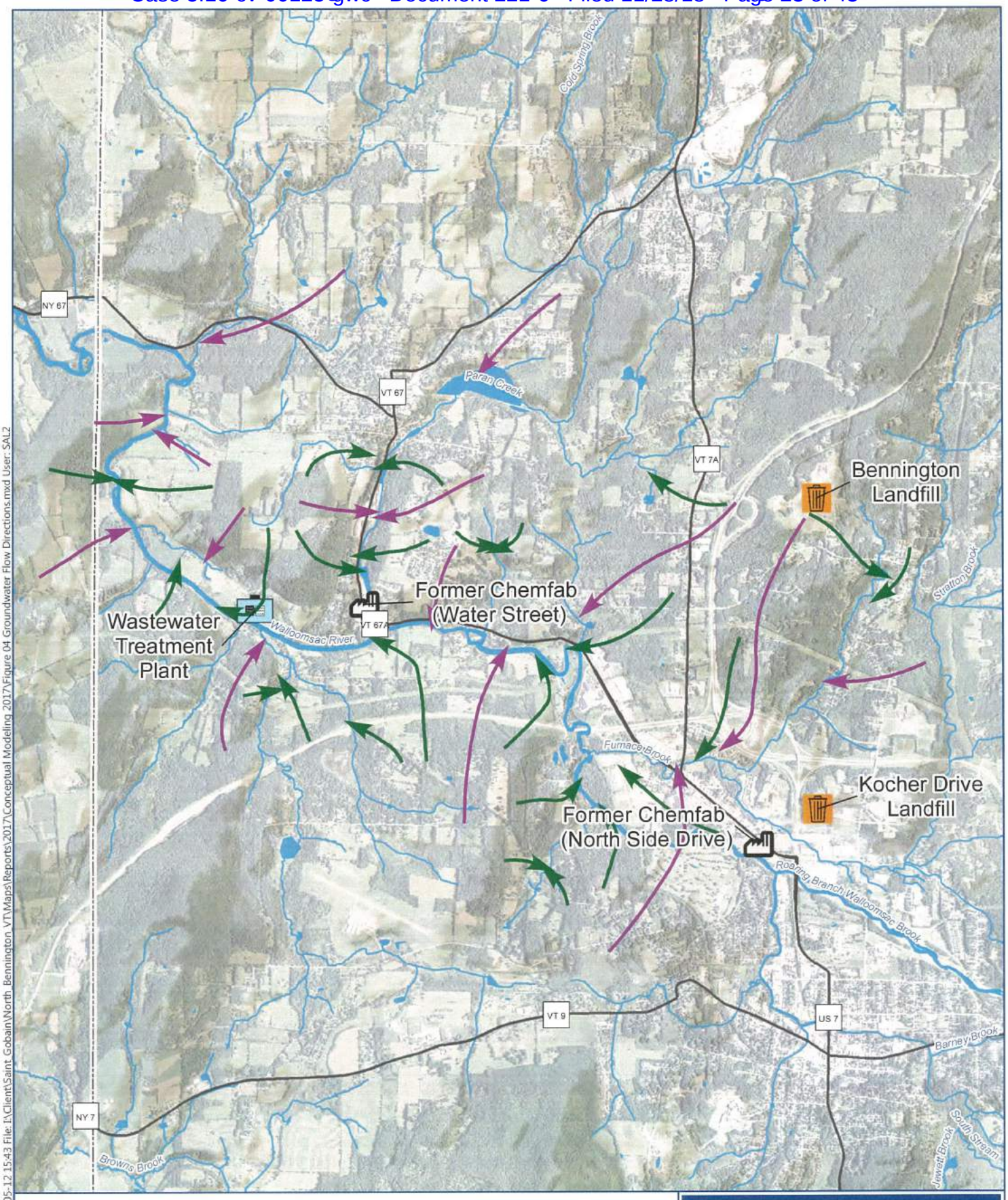




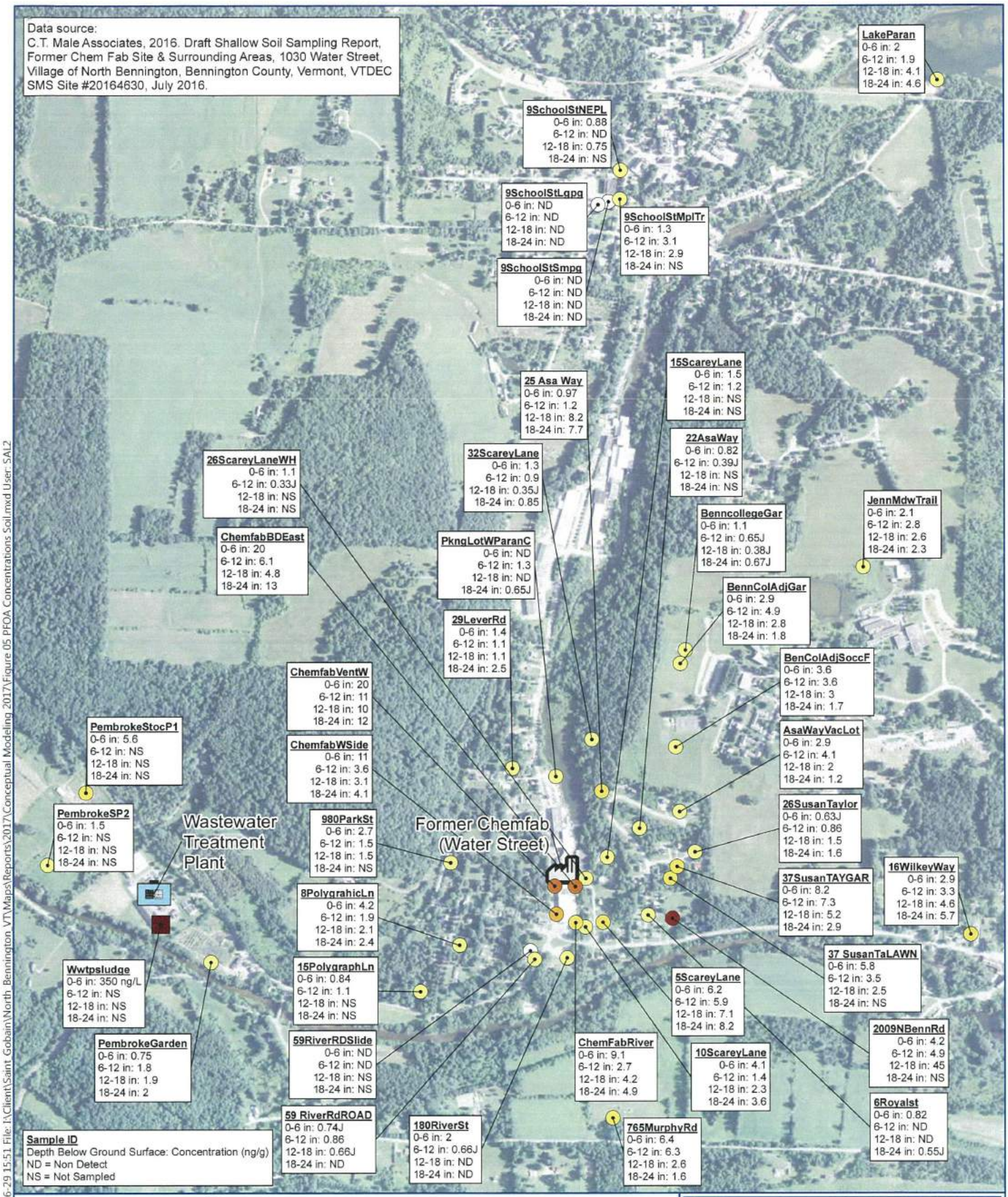
Subject to Protective Order, Produced by Saint-Gobain Performance Plastics, Corp.

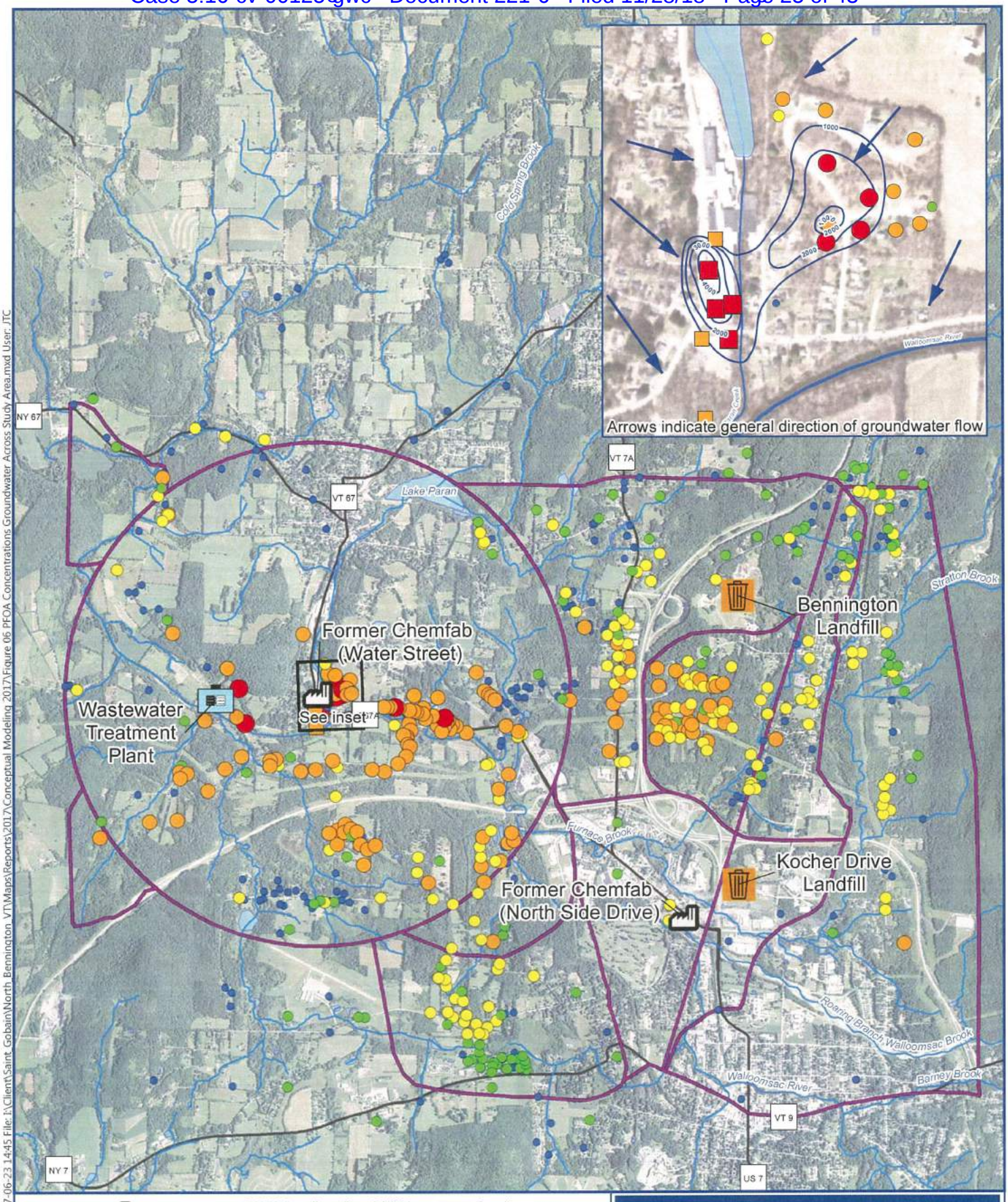
Case 5:16-cv-00225-gwc Document 239-75 Filed 11/26/18 Page 21 of 48


Bennington Landfill
Former Chemfab (Water Street)
Wastewater Treatment Plant
Kocher Drive Landfill
Former Chemfab (North Side Drive)
VT 67
VT 7A
VT 67A
VT 9
NY 67
NY 7
US 7
CR 68
Bedrock Material Type
Breccia
Dolostone
Graywacke
Limestone
Marble
Phyllite
Quartzite
Shale and phyllite
Slate
Source: Ratcliffe, et al., 2011, Bedrock geologic map of Vermont, scale 1:100,000.
Factory
Landfill
Wastewater Treatment Plant
State Boundary
0
4,000
Feet
BARR
BEDROCK GEOLOGY
North Bennington, VT
Saint-Gobain
FIGURE 3
Barr Footer: ArcGIS 10.4, 2017-05-12 15:43 File: I:\Client\Saint_Gobain\North_Bennington_VT\Maps\Reports\2017\Conceptual Modeling 2017\Figure 03 Bedrock Geology Simplified.mxd User: SAL2

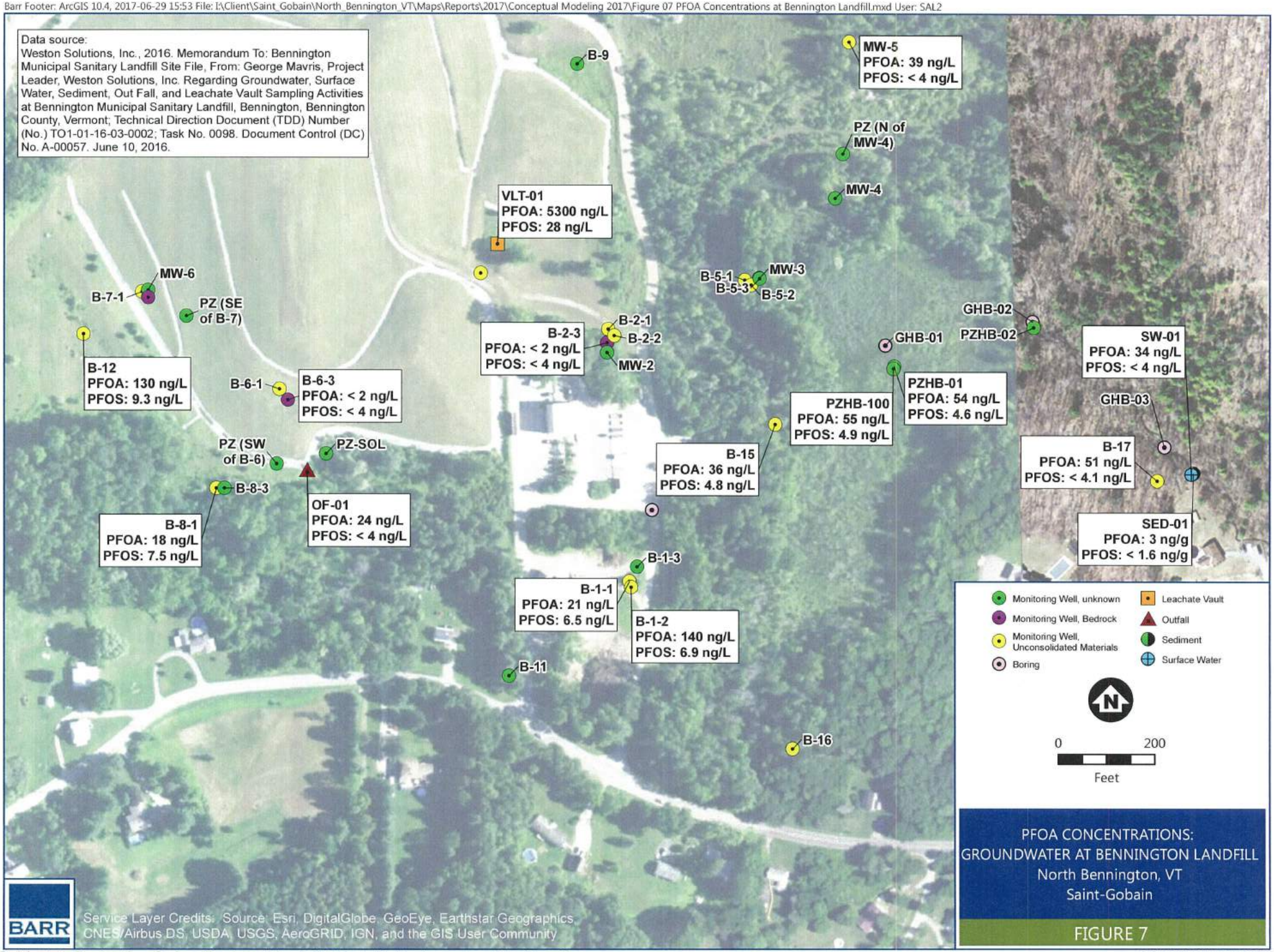


Barr Footer: ArcGIS 10.4, 2017-05-12 15:43 File: I:\Client\Saint Gobain\North Bennington_VT\Maps\Reports\2017\Conceptual Modeling 2017\Figure 04 Groundwater Flow Directions.mxd User: SAL2

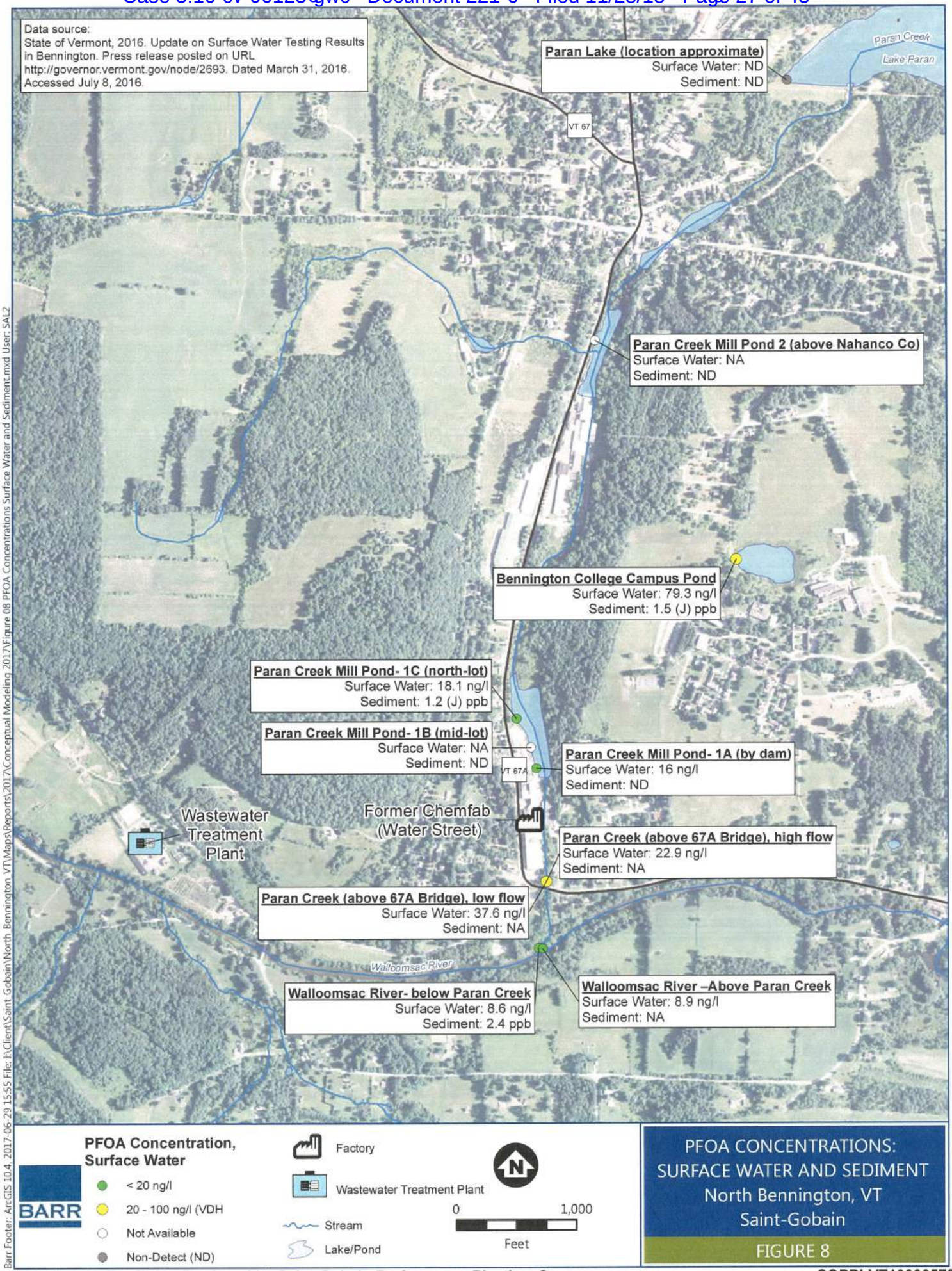

Data source:
C.T. Male Associates, 2016. Draft Shallow Soil Sampling Report, Former Chem Fab Site & Surrounding Areas, 1030 Water Street, Village of North Bennington, Bennington County, Vermont, VTDEC SMS Site #20164630, July 2016.
LakeParan
0-6 in: 2
6-12 in: 1.9
12-18 in: 4.1
18-24 in: 4.6
9SchoolStNEPL
0-6 in: 0.88
6-12 in: ND
12-18 in: 0.75
18-24 in: NS
9SchoolStLgpg
0-6 in: ND
6-12 in: ND
12-18 in: ND
18-24 in: ND
9SchoolStMplTr
0-6 in: 1.3
6-12 in: 3.1
12-18 in: 2.9
18-24 in: NS
9SchoolStSmpg
0-6 in: ND
6-12 in: ND
12-18 in: ND
18-24 in: ND
15ScareyLane
0-6 in: 1.5
6-12 in: 1.2
12-18 in: NS
18-24 in: NS
25 Asa Way
0-6 in: 0.97
6-12 in: 1.2
12-18 in: 8.2
18-24 in: 7.7
22AsaWay
0-6 in: 0.82
6-12 in: 0.39J
12-18 in: NS
18-24 in: NS
32ScareyLane
0-6 in: 1.3
6-12 in: 0.9
12-18 in: 0.35J
18-24 in: 0.85
26ScareyLaneWH
0-6 in: 1.1
6-12 in: 0.33J
12-18 in: NS
18-24 in: NS
JennMdwTrail
0-6 in: 2.1
6-12 in: 2.8
12-18 in: 2.6
18-24 in: 2.3
BenncollegeGar
0-6 in: 1.1
6-12 in: 0.65J
12-18 in: 0.38J
18-24 in: 0.67J
ChemfabBDEast
0-6 in: 20
6-12 in: 6.1
12-18 in: 4.8
18-24 in: 13
PkngLotWParanC
0-6 in: ND
6-12 in: 1.3
12-18 in: ND
18-24 in: 0.65J
BennColAdjGar
0-6 in: 2.9
6-12 in: 4.9
12-18 in: 2.8
18-24 in: 1.8
29LeverRd
0-6 in: 1.4
6-12 in: 1.1
12-18 in: 1.1
18-24 in: 2.5
BenColAdjSoccF
0-6 in: 3.6
6-12 in: 3.6
12-18 in: 3
18-24 in: 1.7
ChemfabVentW
0-6 in: 20
6-12 in: 11
12-18 in: 10
18-24 in: 12
AsaWayVacLot
0-6 in: 2.9
6-12 in: 4.1
12-18 in: 2
18-24 in: 1.2
PembrokeStocP1
0-6 in: 5.6
6-12 in: NS
12-18 in: NS
18-24 in: NS
ChemfabWSide
0-6 in: 11
6-12 in: 3.6
12-18 in: 3.1
18-24 in: 4.1
26SusanTaylor
0-6 in: 0.63J
6-12 in: 0.86
12-18 in: 1.5
18-24 in: 1.6
PembrokeSP2
0-6 in: 1.5
6-12 in: NS
12-18 in: NS
18-24 in: NS
Wastewater Treatment Plant
980ParkSt
0-6 in: 2.7
6-12 in: 1.5
12-18 in: 1.5
18-24 in: NS
Former Chemfab (Water Street)
16WilkeyWay
0-6 in: 2.9
6-12 in: 3.3
12-18 in: 4.6
18-24 in: 5.7
37SusanTAYGAR
0-6 in: 8.2
6-12 in: 7.3
12-18 in: 5.2
18-24 in: 2.9
8PolygrahicLn
0-6 in: 4.2
6-12 in: 1.9
12-18 in: 2.1
18-24 in: 2.4
37 SusanTaLAWN
0-6 in: 5.8
6-12 in: 3.5
12-18 in: 2.5
18-24 in: NS
Wwtpsludge
0-6 in: 350 ng/L
6-12 in: NS
12-18 in: NS
18-24 in: NS
15PolygraphLn
0-6 in: 0.84
6-12 in: 1.1
12-18 in: NS
18-24 in: NS
5ScareyLane
0-6 in: 6.2
6-12 in: 5.9
12-18 in: 7.1
18-24 in: 8.2
2009NBennRd
0-6 in: 4.2
6-12 in: 4.9
12-18 in: 45
18-24 in: NS
PembrokeGarden
0-6 in: 0.75
6-12 in: 1.8
12-18 in: 1.9
18-24 in: 2
59RiverRDSlide
0-6 in: ND
6-12 in: ND
12-18 in: NS
18-24 in: NS
ChemFabRiver
0-6 in: 9.1
6-12 in: 2.7
12-18 in: 4.2
18-24 in: 4.9
10ScareyLane
0-6 in: 4.1
6-12 in: 1.4
12-18 in: 2.3
18-24 in: 3.6
6Royalst
0-6 in: 0.82
6-12 in: ND
12-18 in: ND
18-24 in: 0.55J
59 RiverRdROAD
0-6 in: 0.74J
6-12 in: 0.86
12-18 in: 0.66J
18-24 in: ND
180RiverSt
0-6 in: 2
6-12 in: 0.66J
12-18 in: ND
18-24 in: ND
765MurphyRd
0-6 in: 6.4
6-12 in: 6.3
12-18 in: 2.6
18-24 in: 1.6
Sample ID
Depth Below Ground Surface: Concentration (ng/g)
ND = Non Detect
NS = Not Sampled
PFOA Maximum Value (ng/g)
Non Detect
< 5
5 - 10.
10 - 15
15 - 20
> 20
Sewer Sludge Sample (ng/l)
Factory
Wastewater Treatment Plant
N
0
1,000
Feet
BARR
PFOA CONCENTRATIONS: SOIL
MARCH 2016
North Bennington, VT
Saint-Gobain
FIGURE 5
Barr Footer: ArcGIS 10.4, 2017-06-29 15:51 File: I:\Client\Saint Gobain\North Bennington VT\Maps\Reports\2017\Conceptual Modeling 2017\Figure 05 PFOA Concentrations Soil.mxd User: SAL2


Arrows indicate general direction of groundwater flow
Former Chemfab (Water Street)
See inset
Wastewater Treatment Plant
Bennington Landfill
Kocher Drive Landfill
Former Chemfab (North Side Drive)
Lake Paran
Cold Spring Brook
Stratton Brook
Furnace Brook
Roaring Branch
Walloomsac Brook
Walloomsac River
Barney Brook
NY 67
VT 67
VT 7A
VT 9
NY 7
US 7
Factory
Landfill
Wastewater Treatment Plant
PFOA Isoconcentration Contour
VTDEC Sampling Result (3/23/2017)
> 1000
100 - 1000
20 - 100
< 20
Non Detect
Chemfab Water Street Sampling Result (12/2016)
> 1000
100 - 1000
20 - 100
< 20
Sampling Boundary
Stream
Lake/Pond
0
4,000
Feet
BARR
PFOA CONCENTRATIONS: GROUNDWATER ACROSS STUDY AREA
North Bennington, VT
Saint-Gobain
FIGURE 6
Barr Footer: ArcGIS 10.4.1, 2017-06-23 14:45 File: I:\Client\Saint_Gobain\North_Bennington_VT\Maps\Reports\2017\Conceptual Modeling 2017\Figure 06 PFOA Concentrations Groundwater Across Study Area.mxd User: JTC

Barr Footer: ArcGIS 10.4, 2017-06-29 15:53 File: I:\Client\Saint_Gobain\North_Bennington_VT\Maps\Reports\2017\Conceptual Modeling 2017\Figure 07 PFOA Concentrations at Bennington Landfill.mxd User: SAL2



Case 5:16-cv-00225-gwc Document 224-75 Filed 11/26/18 Page 26 of 43


Data source:
State of Vermont, 2016. Update on Surface Water Testing Results in Bennington. Press release posted on URL http://governor.vermont.gov/node/2693. Dated March 31, 2016. Accessed July 8, 2016.
Paran Lake (location approximate)
Surface Water: ND
Sediment: ND
Paran Creek
Lake Paran
VT 67
Paran Creek Mill Pond 2 (above Nahanco Co)
Surface Water: NA
Sediment: ND
Bennington College Campus Pond
Surface Water: 79.3 ng/l
Sediment: 1.5 (J) ppb
Paran Creek Mill Pond- 1C (north-lot)
Surface Water: 18.1 ng/l
Sediment: 1.2 (J) ppb
Paran Creek Mill Pond- 1B (mid-lot)
Surface Water: NA
Sediment: ND
VT 67A
Paran Creek Mill Pond- 1A (by dam)
Surface Water: 16 ng/l
Sediment: ND
Wastewater Treatment Plant
Former Chemfab (Water Street)
Paran Creek (above 67A Bridge), high flow
Surface Water: 22.9 ng/l
Sediment: NA
Paran Creek (above 67A Bridge), low flow
Surface Water: 37.6 ng/l
Sediment: NA
Walloomsac River
Walloomsac River- below Paran Creek
Surface Water: 8.6 ng/l
Sediment: 2.4 ppb
Walloomsac River –Above Paran Creek
Surface Water: 8.9 ng/l
Sediment: NA
PFOA Concentration, Surface Water
< 20 ng/l
20 - 100 ng/l (VDH
Not Available
Non-Detect (ND)
Factory
Wastewater Treatment Plant
Stream
Lake/Pond
N
0
1,000
Feet
BARR
PFOA CONCENTRATIONS:
SURFACE WATER AND SEDIMENT
North Bennington, VT
Saint-Gobain
FIGURE 8
Barr Footer: ArcGIS 10.4, 2017-06-29 15:55 File: J:\Client\Saint-Gobain\North Bennington VT\Maps\Reports\2017\Conceptual Modeling 2017\Figure 08 PFOA Concentrations Surface Water and Sediment.mxd User: SAL2

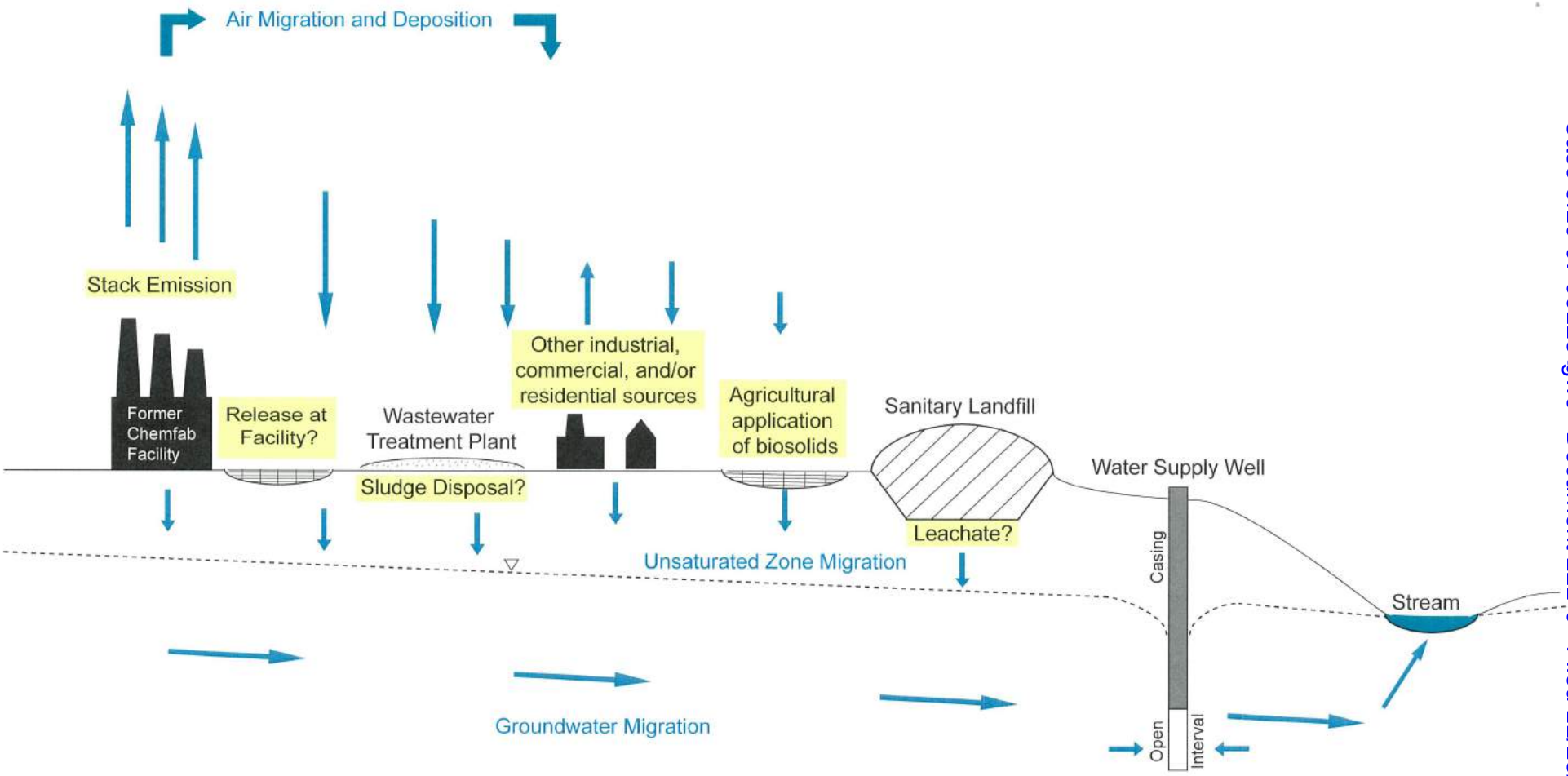


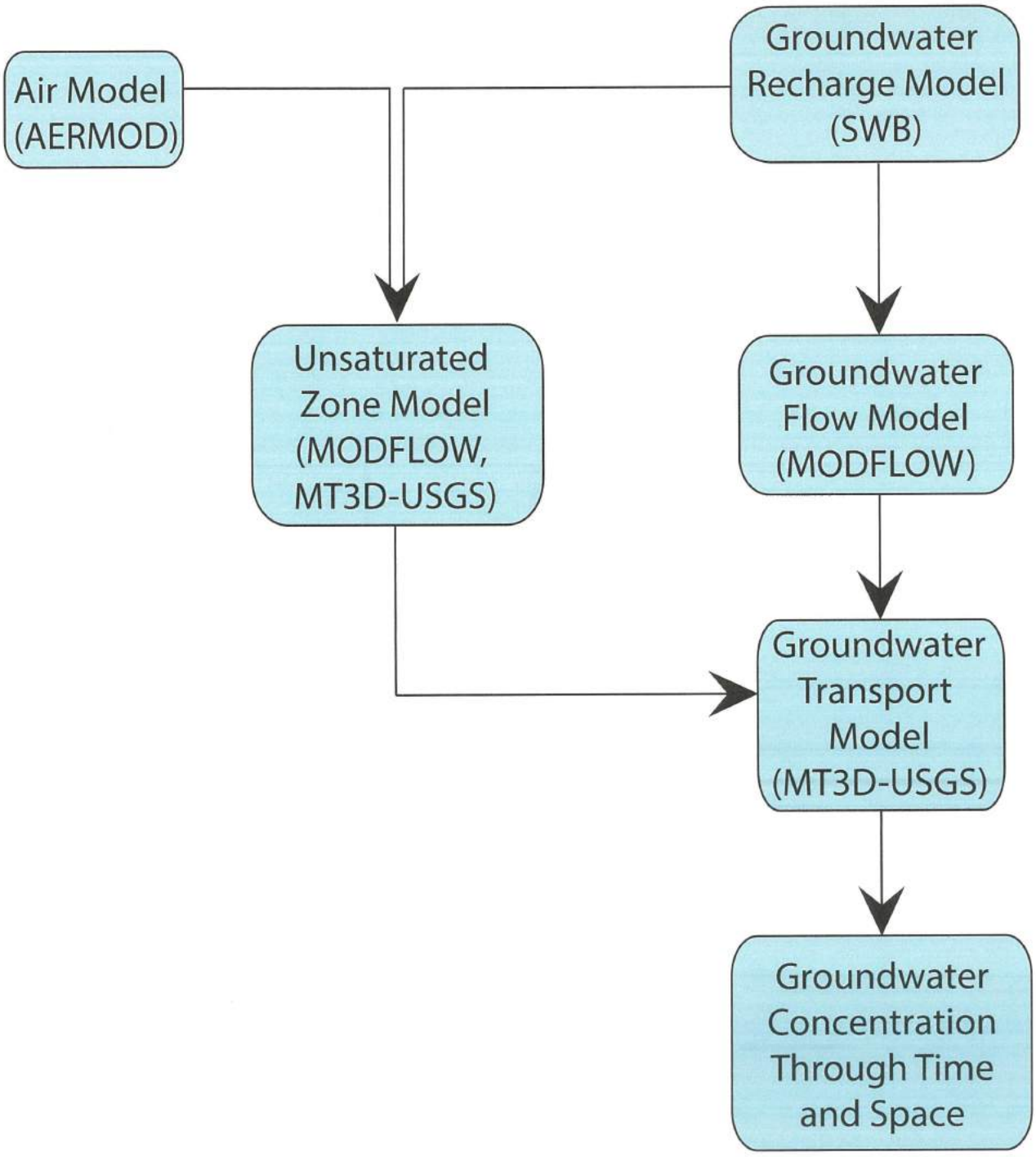
Figure 9

Not Drawn to Scale

CONCEPT OF POTENTIAL PFOA RELEASE AND MIGRATION
Conceptual Modeling of PFOA Fate and Transport
North Bennington, Vermont
Saint-Gobain

Subject to Protective Order, Produced by Saint-Gobain Performance Plastics, Corp.

Case 5:16-cv-00225-gwc Document 218-75 Filed 11/27/18 Page 28 of 48



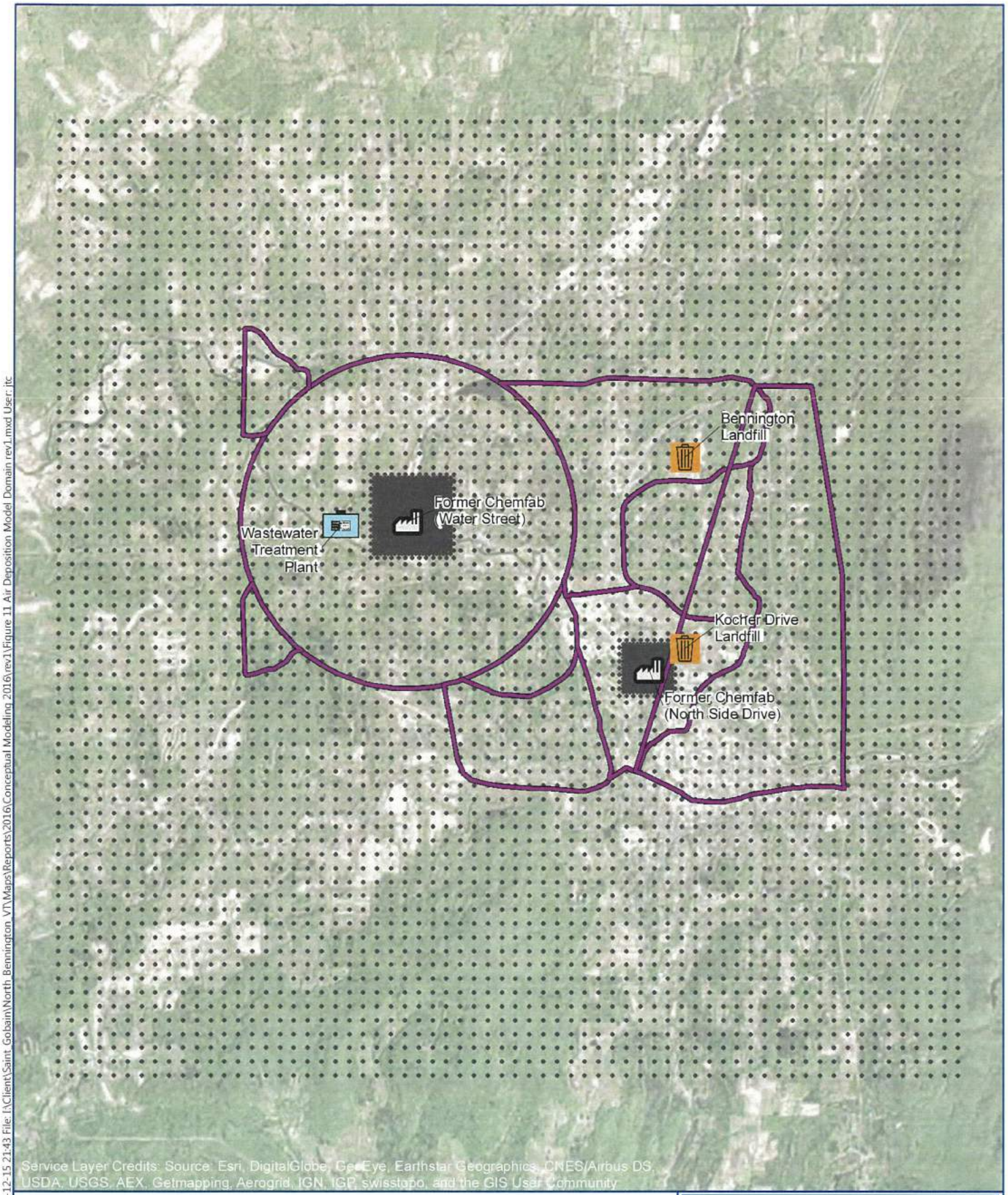
P:\Mpls\32 NY\42\32421001 PFOA Fate and Transport\WorkFiles\Bennington\Reports\Conceptual Modeling\Rev1\Figures\source\Model Process Flow Chart rev1.ai

BARR

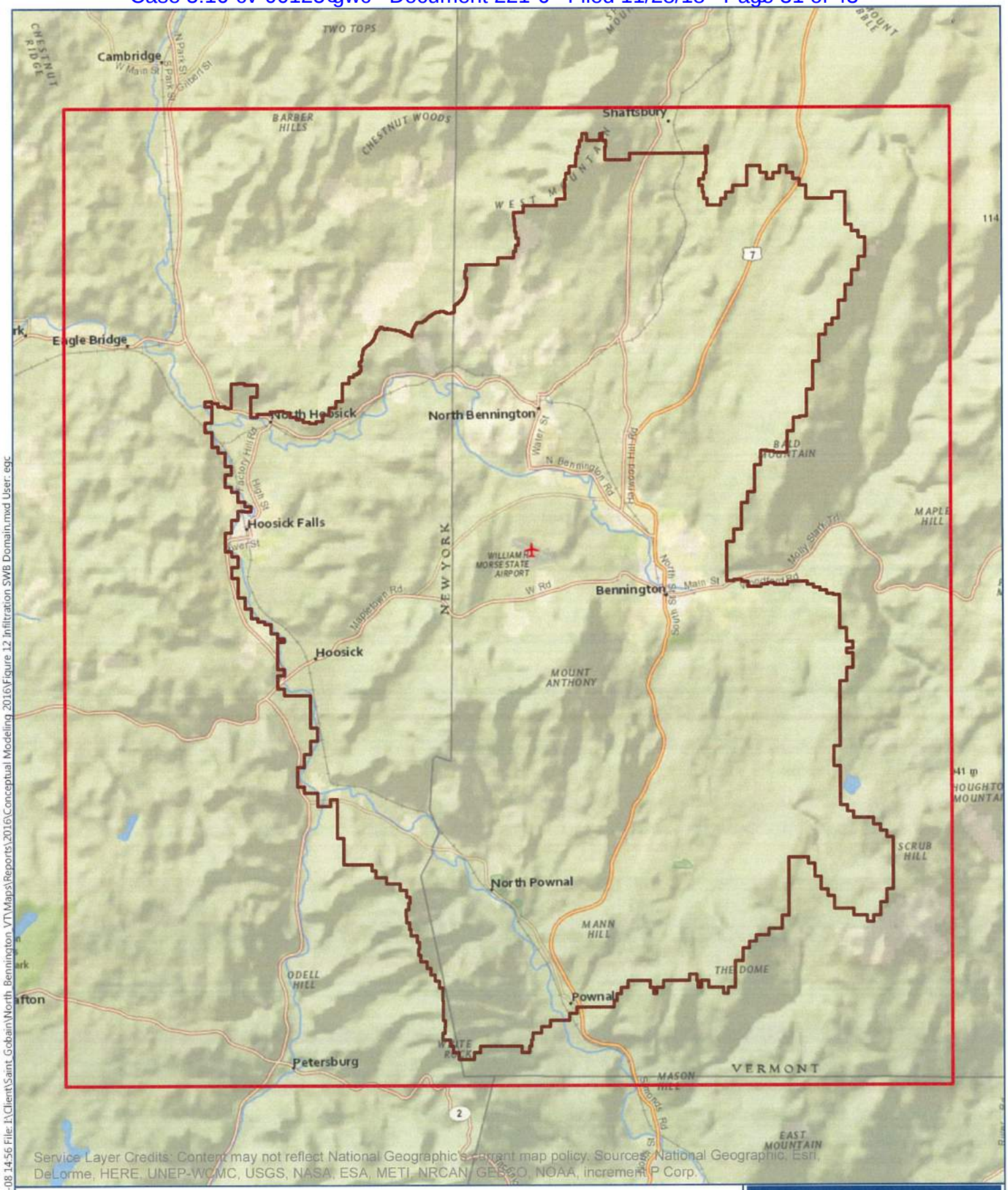
Figure 10

MODEL PROCESS FLOW CHART
Conceptual Modeling of PFOA Fate and Transport
North Bennington, Vermont
Saint-Gobain

Subject to Protective Order, Produced by Saint-Gobain Performance Plastics, Corp.



Barr Footer: ArcGIS 10.4.1, 2016-12-15 21:43 File: I:\Client\Saint_Gobain\North_Bennington_VT\Maps\Reports\2016\Conceptual Modeling_2016\rev1\Figure 11 Air Deposition Model Domain rev1.mxd User: jtc



BARR

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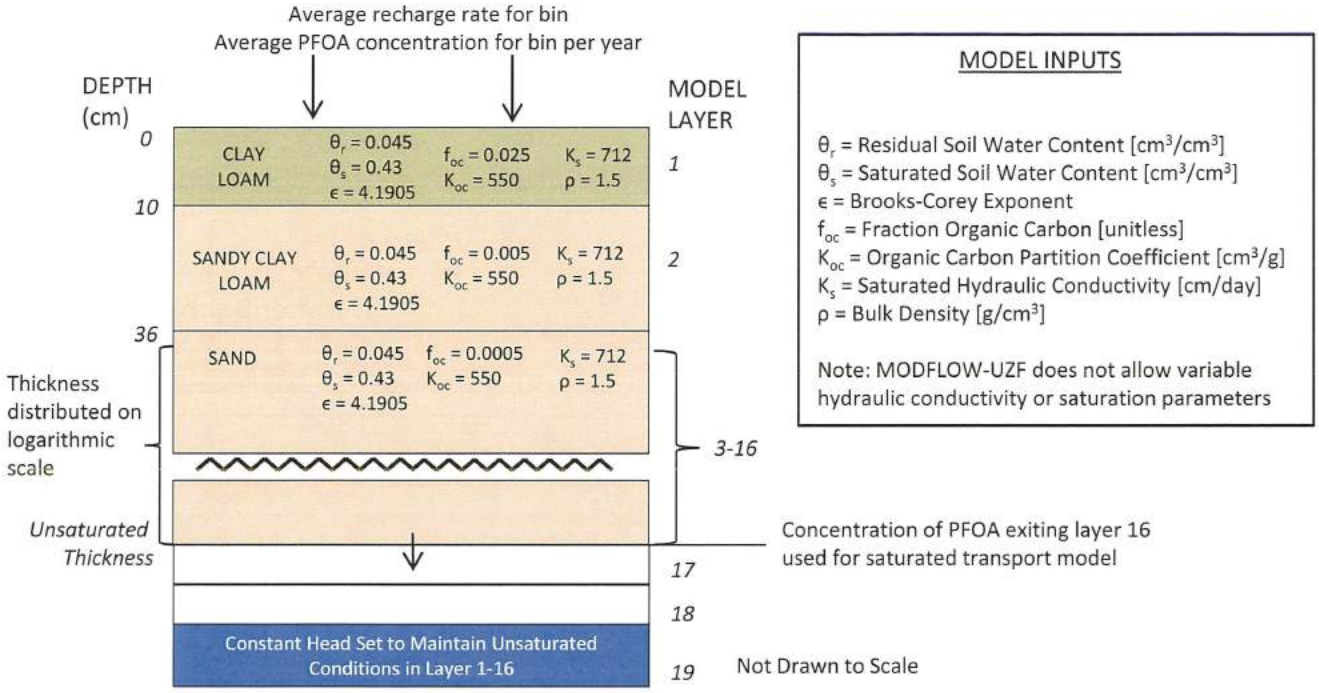
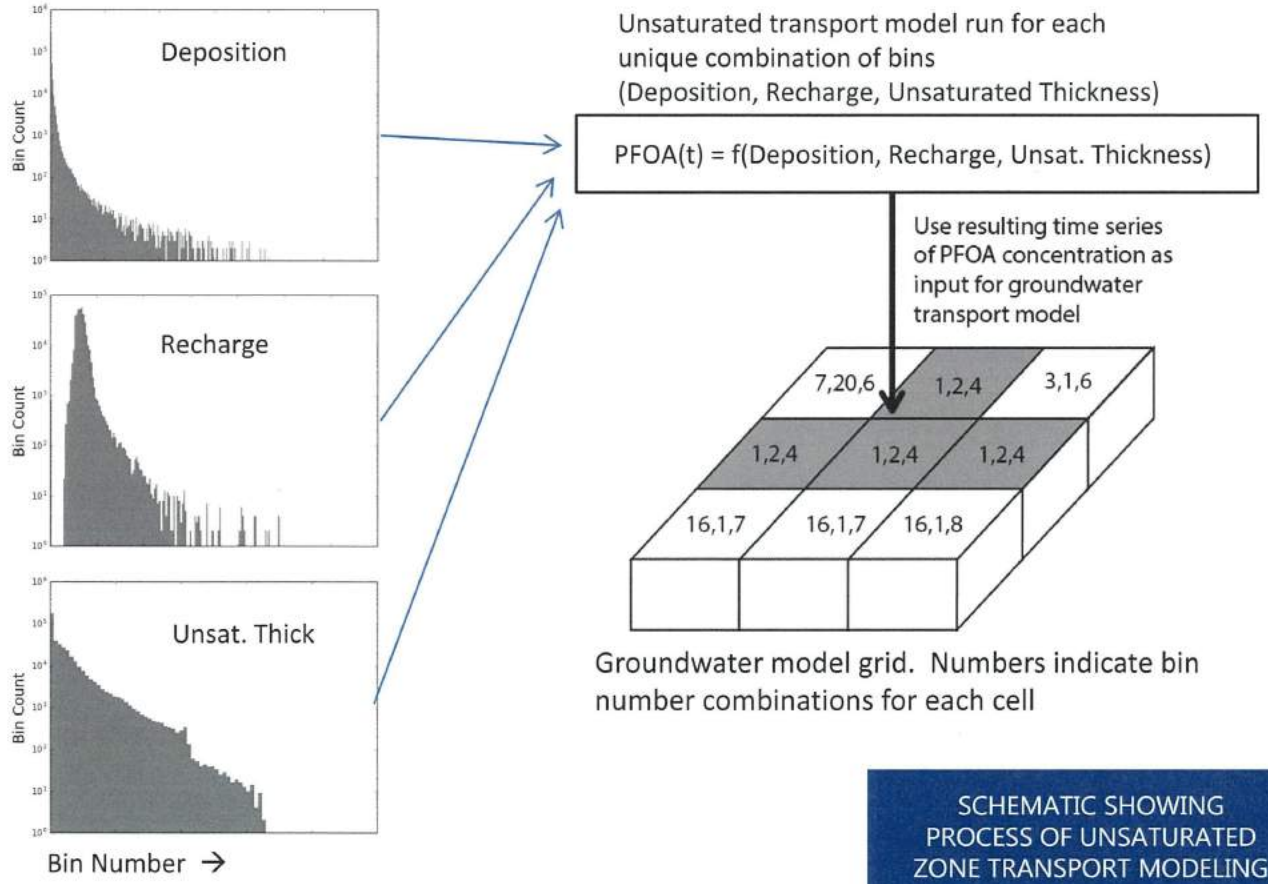
Case 5:16-cv-00125-gwc Document 221-6 Filed 11/28/18 Page 32 of 43





SCHEMATIC SHOWING PROCESS OF UNSATURATED ZONE TRANSPORT MODELING

North Bennington, VT
Saint-Gobain

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FIGURE 3.3

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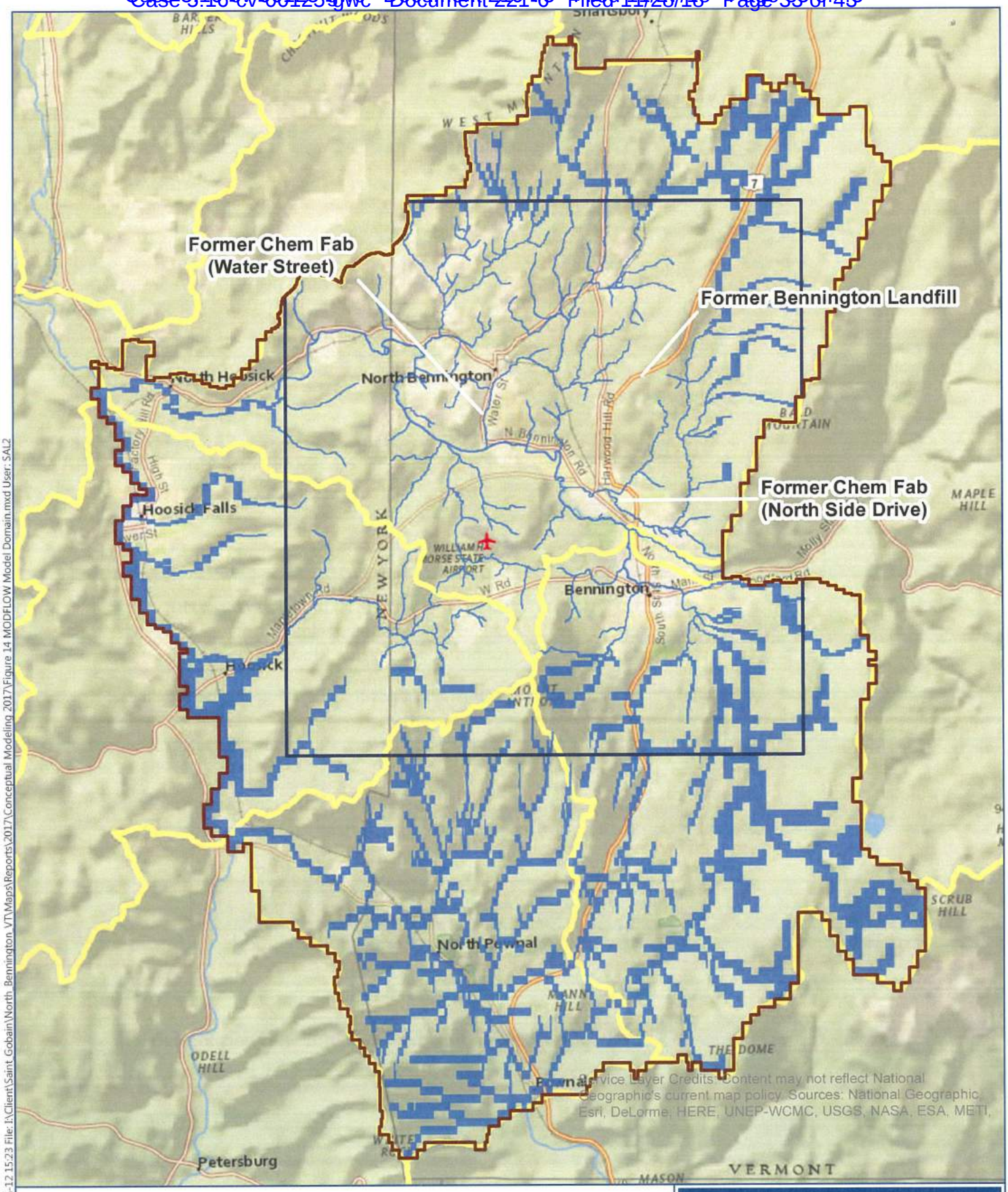
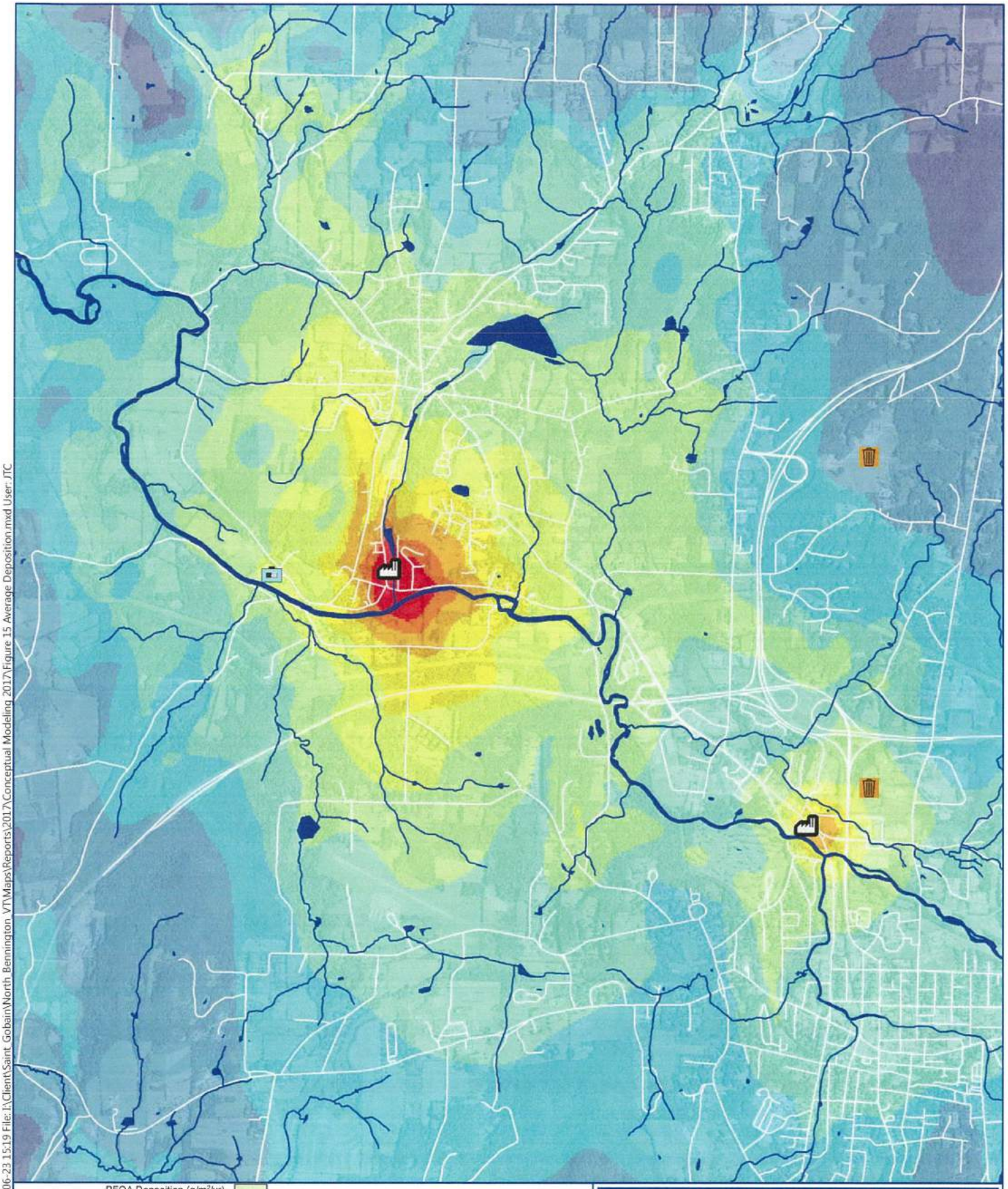
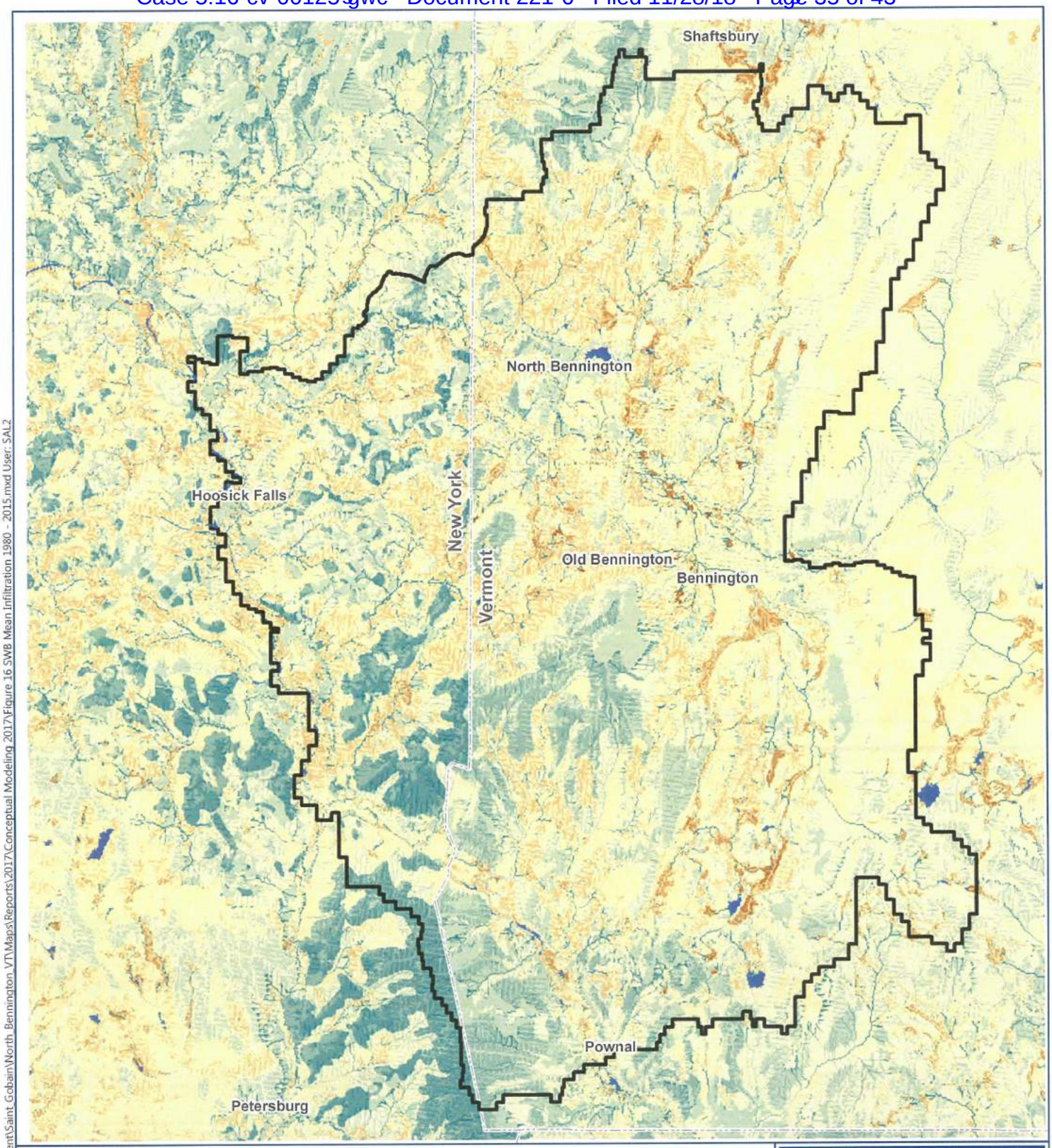


Subject to Protective Order, Produced by Saint-Gobain Performance Plastics, Corp.


PFOA Deposition (g/m²/yr)
<1.8e-06
1.8e-06 - 3.2e-06
3.3e-06 - 5.6e-06
5.7e-06 - 1.0e-05
1.1e-05 - 1.8e-05
1.9e-05 - 3.2e-05
3.3e-05 - 5.6e-05
5.7e-05 - 1.0e-04
1.1e-04 - 1.8e-04
1.9e-04 - 3.2e-04
> 3.2e-04
N
0
3,000
Feet
BARR
AVERAGE AIR DEPOSITION RATE (1970-2002)
North Bennington, VT
Saint-Gobain
FIGURE 15
Barr Footer: ArcGIS 10.4.1, 2017-06-23 15:19 File: I:\Client\Saint_Gobain\North_Bennington_VT\Maps\Reports\2017\Conceptual Modeling 2017\Figure 15 Average Deposition.mxd User: JTC



Average Annual Infiltration (in/yr)
8.0 - 10.0
10.1 - 12.0
12.1 - 14.0
14.1 - 16.0
16.1 - 18.0
18.1 - 20.0
20.1 - 22.0
22.1 - 24.0
24.1 - 26.0
> 26.0
Groundwater Model Domain
Water

N
0 1 2
Miles

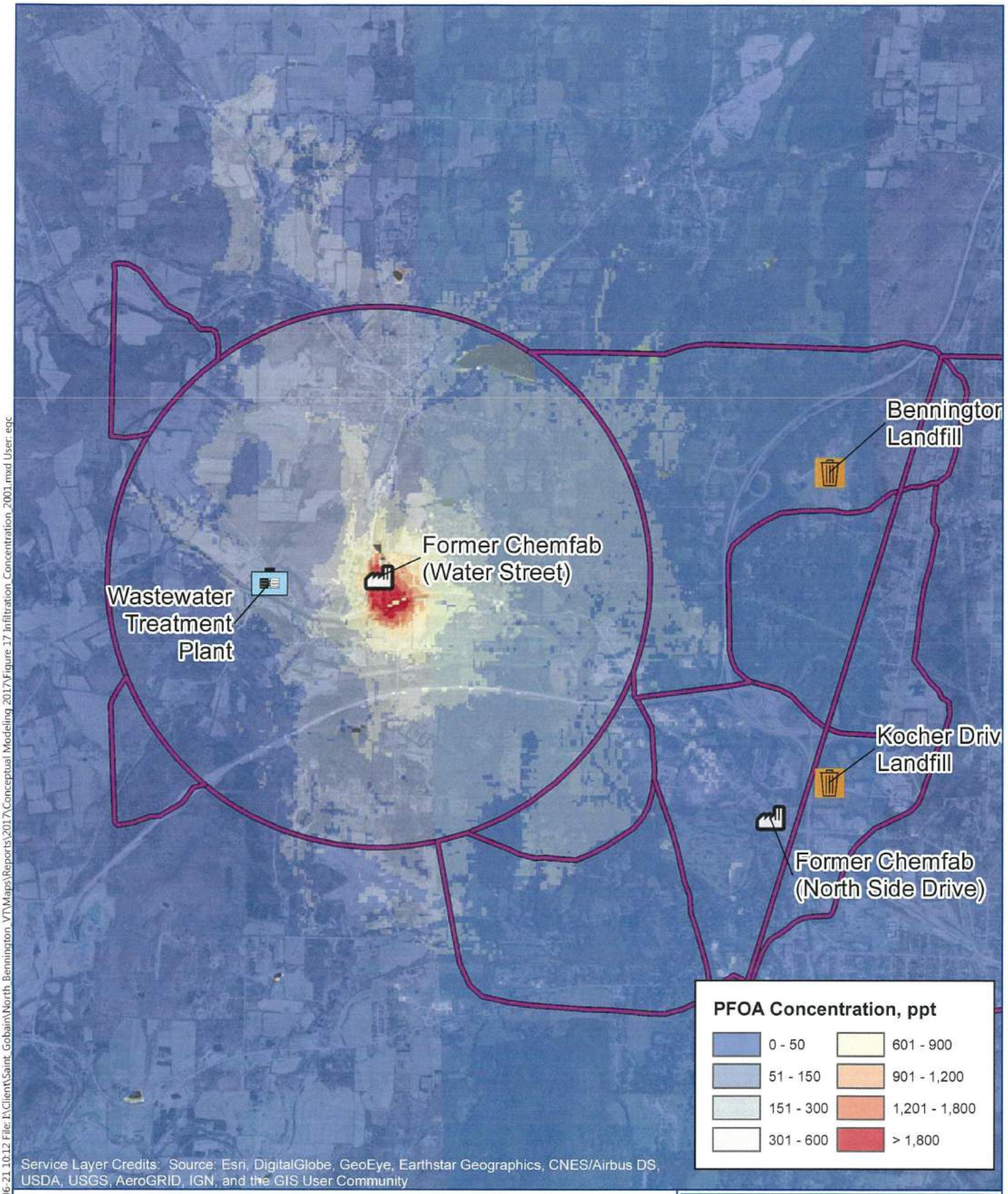
BARR

AVERAGE ANNUAL INFILTRATION FROM SWB MODEL: 1980-2015
North Bennington, VT
Saint-Gobain

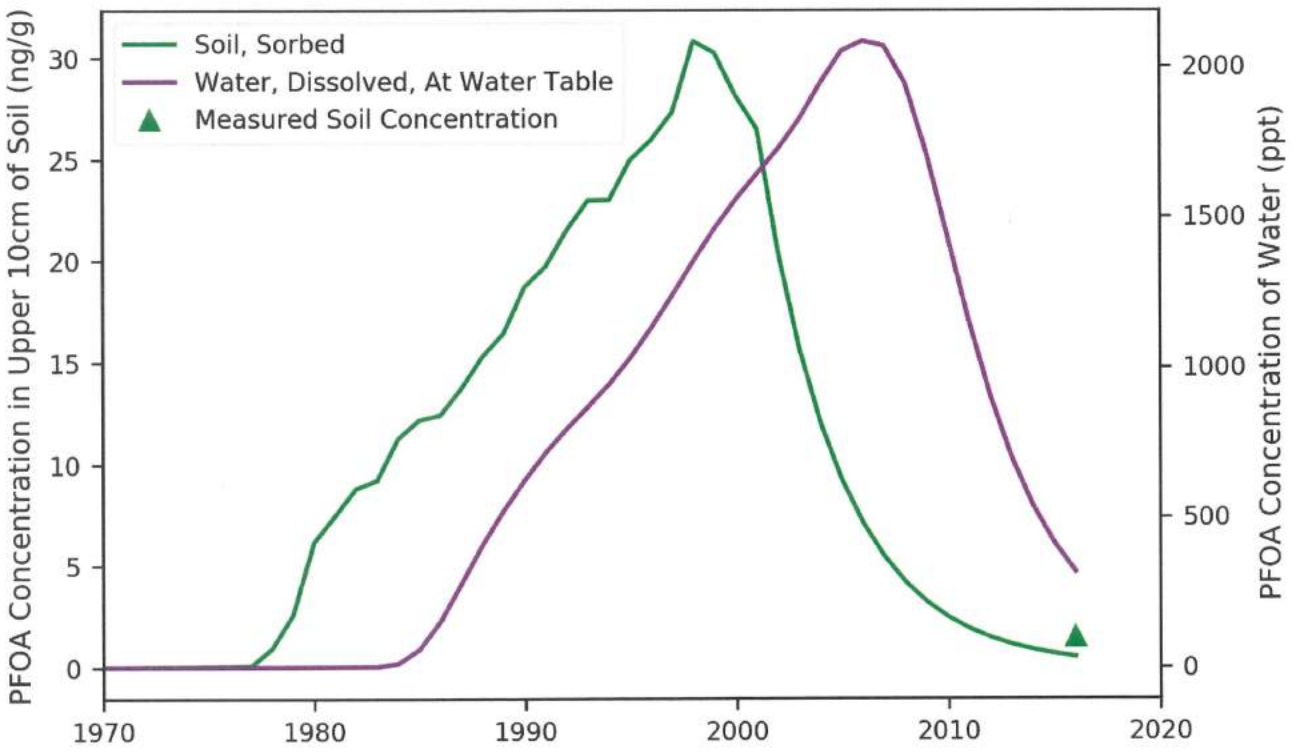
FIGURE 16

Barr Footer: ArcGIS 10.4, 2017-06-20 10:39 File: I:\Client\Saint_Gobain\North_Bennington_VT\Maps\Reports\2017\Conceptual Modeling 2017\Figure 16 SWB Mean Infiltration 1980 - 2015.mxd User: SAL2

Subject to Protective Order, Produced by Saint-Gobain Performance Plastics, Corp.



Barr Footer: ArcGIS 10.4, 2017-06-21 10:12 File: I:\Client\Saint_Gobain\North_Bennington_VT\Maps\Reports\2017\Conceptual Modeling 2017\Figure 17 Infiltration_Concentration_2001.mxd User: egc



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SIMULATED PFOA CONCENTRATIONS IN UNSATURATED ZONE

North Bennington, VT
Saint-Gobain

FIGURE 18

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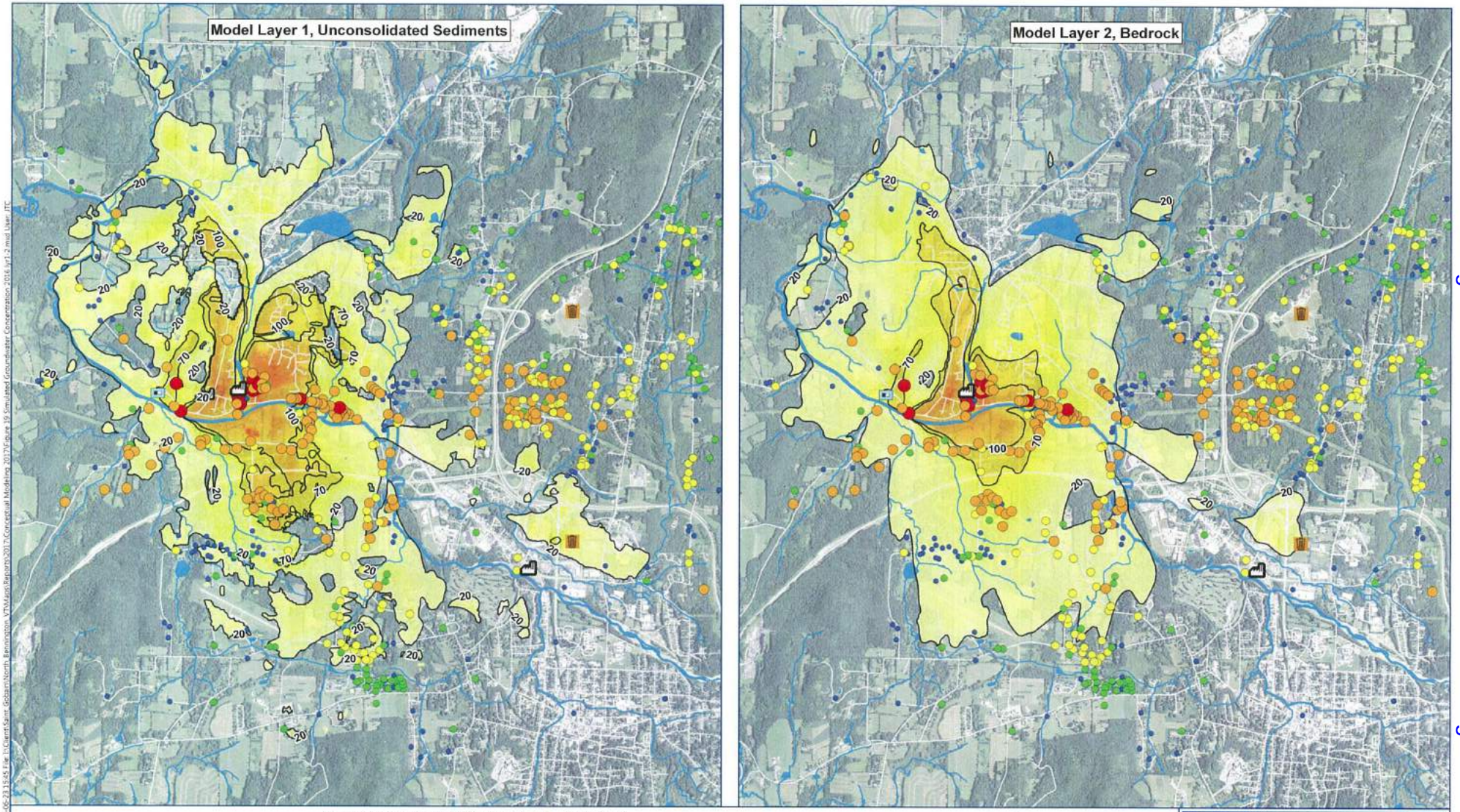
Case 5:16-cv-00225-gwc Document 239-75 Filed 11/27/18 Page 87 of 148



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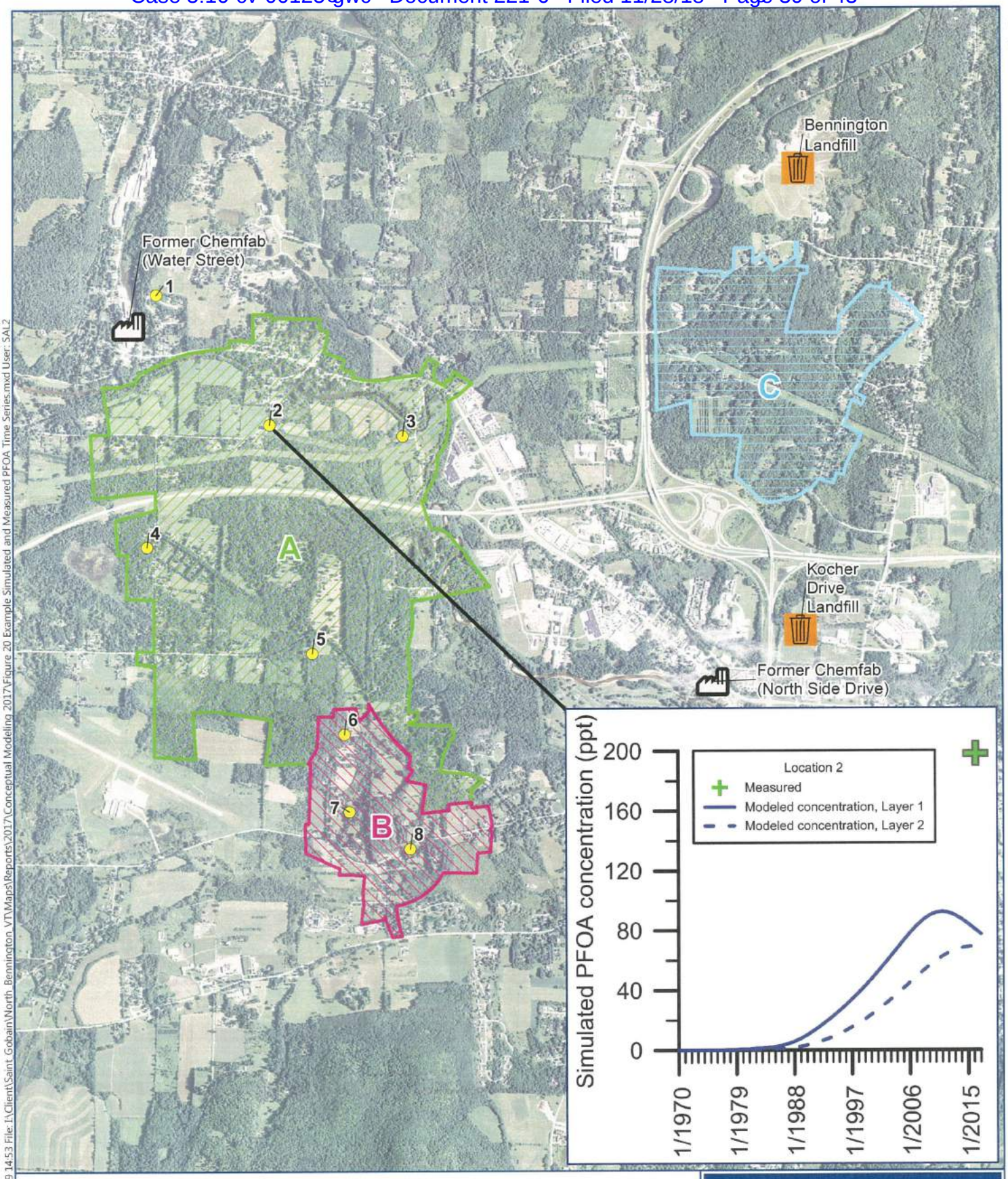
SGPPLVT10000590

Case 5:16-cv-00225-gwc Document 229-75 Filed 11/27/18 Page 38 of 43

Case 5:16-cv-00125-gwc Document 221-6 Filed 11/28/18 Page 39 of 43



EXAMPLE MEASURED AND SIMULATED PFOA TIME SERIES AT A PRIVATE WELL
North Bennington, VT
Saint-Gobain

FIGURE 20

Barr Footer: ArcGIS 10.4, 2017-06-29 14:53 File: I:\Client\Saint-Gobain\North_Bennington_VT\Maps\Reports\2017\Conceptual Modeling 2017\Figure 20 Example Simulated and Measured PFOA Time Series.mxd User: SAL2

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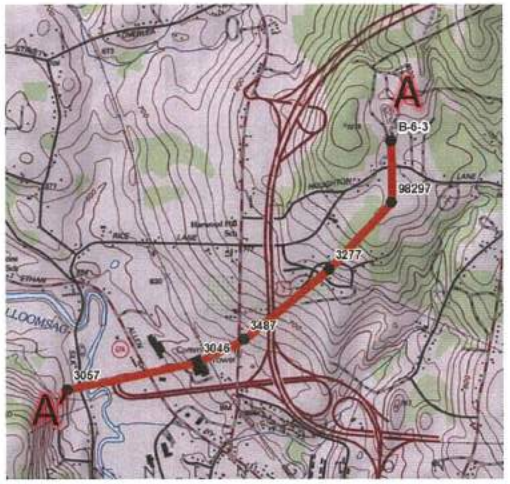
Subject to Protective Order, Produced by Saint-Gobain Performance Plastics, Corp.



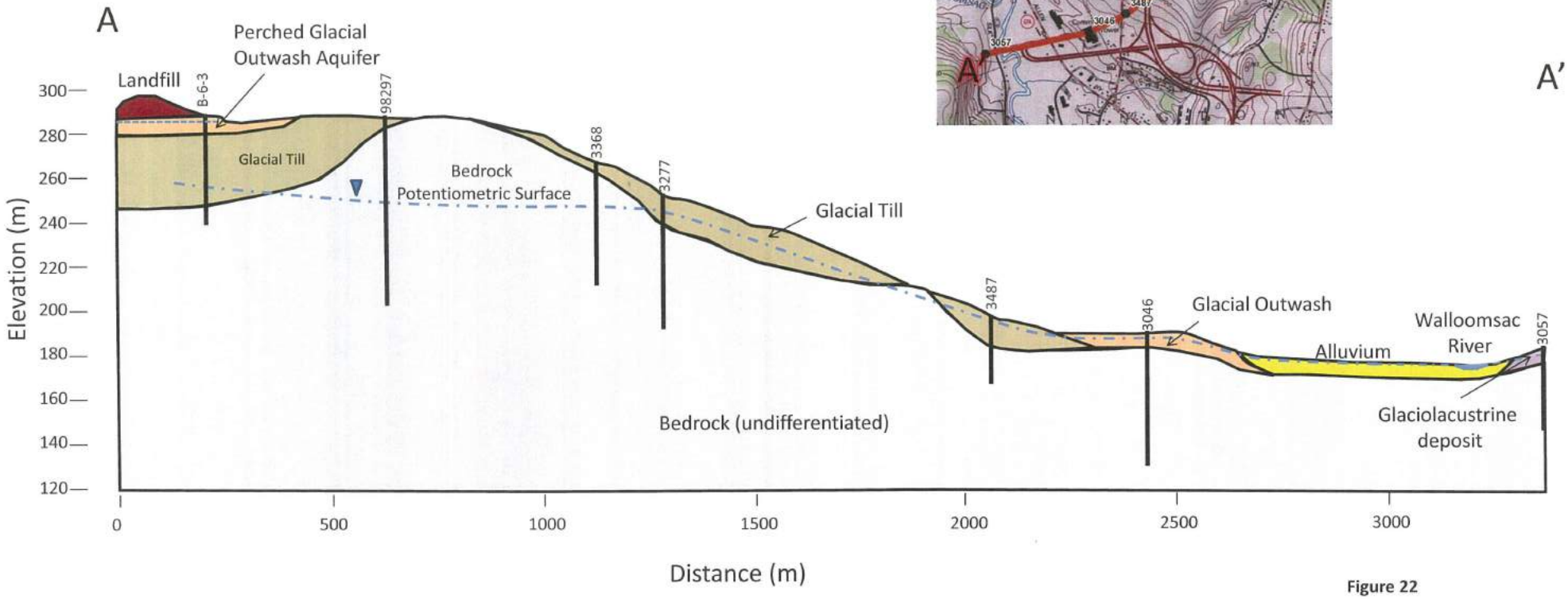


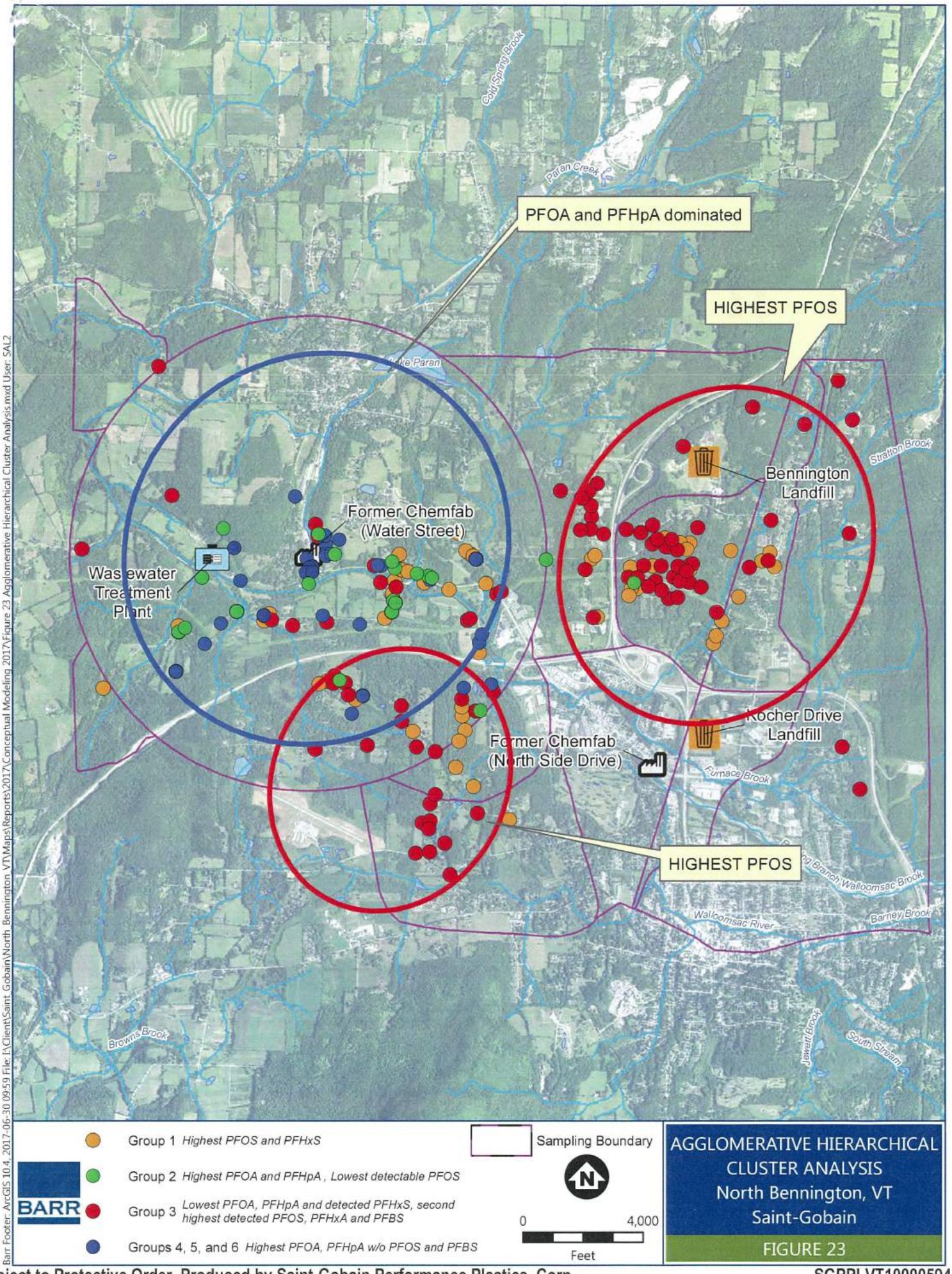
Figure 22

Bennington Landfill Flow Cross Section
Conceptual Modeling of PFOA Fate and Transport
North Bennington, VT
Saint-Gobain

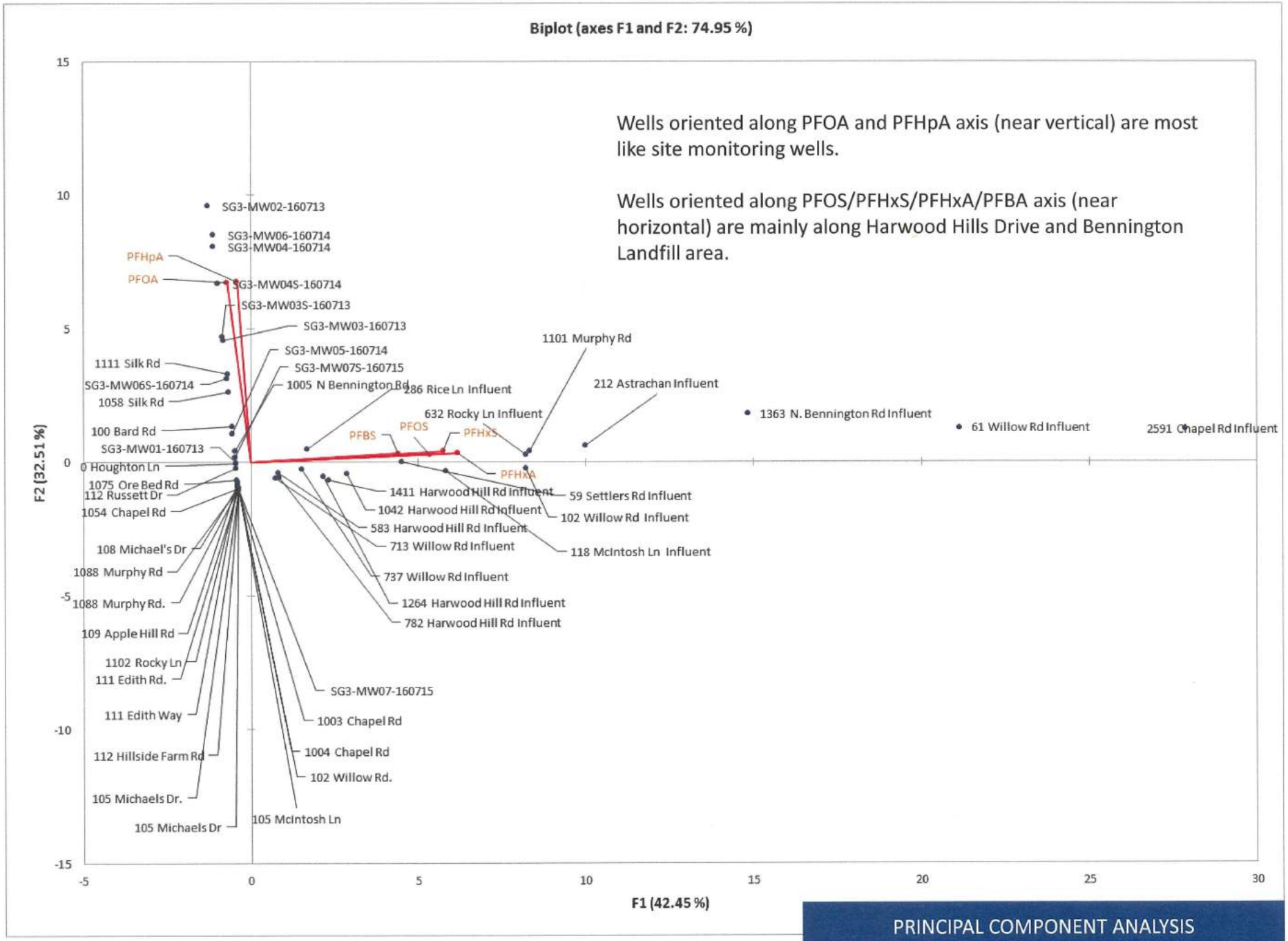
P:\Mpls\32 NY\42\32421001 PFOA Fate and Transport\WorkFiles\Bennington\Reports\Conceptual Modeling\Rev1\Figures\source\Figure22_Cross_Section_From_Landfill_v2.pptx

Subject to Protective Order, Produced by Saint-Gobain Performance Plastics, Corp.

Case 5:16-cv-00225-gwc Document 228-75 Filed 11/27/18 Page 41 of 48



Subject to Protective Order, Produced by Saint-Gobain Performance Plastics, Corp.



PRINCIPAL COMPONENT ANALYSIS
North Bennington, VT
Saint-Gobain

FIGURE 24

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Case 5:16-cv-00125-gwc Document 228-75 Filed 11/27/18 Page 48 of 48